1. INTRODUCTION

Conventional microstrip antennas in general have a conducting patch printed on a grounded microwave substrate and have the attractive features of low profile, light weight, easy fabrication and conformability to mounting. However microstrip antennas inherently have a narrow bandwidth and bandwidth enhancement is usually demanded for practical applications. In addition, applications in present day mobile communication systems usually require smaller antenna size in order to meet the miniaturization requirements of mobile units. Thus size reduction and bandwidth enhancement are becoming major design considerations for practical applications of microstrip antennas. For this reason, studies to achieve compact and broadband operations of microstrip antennas have greatly increased. In addition microstrip antennas are manufactured using printed circuit technology, so that mass production can be achieved at a low cost.

Howell has defined microstrip antenna as, "MICROSTRIPS ANTENNA consist of a planar resonant radiating element parallel to but separated from a ground plane by thin dielectric substrate (t << λ)”, where ‘t’ is the thickness of substrate and ‘λ’ is wavelength.

Microstrip antenna technology has been the most rapidly developing topic in the antenna field in the last fifteen years, receiving the creative attentions of academic, industrial and government engineers and researchers throughout the world.

The electromagnetic simulation of the proposed antenna can be carried out using IE3D software of zeland software. VSWR, input impedance, return loss, smith chart, directivity, antenna gain, radiating efficiency and radiation pattern etc. can be evaluated.

The printed radiating element is electrically driven with respect to the ground plane. A wide range of dielectric substrate thickness and permittivity can be used and of course the special case when the strip and ground are separated by an air space. The dielectric constant of substrate should be low (ε_r ≈ 4.4). Low dielectric constant enhances the microstrip line feed, which account for radiation. However other considerations like low loss at higher frequencies dictate the use of substrate material whose dielectric constant may vary from 2 to 4.4 with considerable loss tangent.
1.1 HISTORICAL DEVELOPMENT

The microstrip patch antenna is dated back to as late as Prof. Deschamp and Gutton originally proposed the concept of printed antenna in 1950s. The first prototype can be imagined as a thin radiating metal piece of arbitrary shape, separated from a ground plane by a dielectric substrate, as referred by Fig. 1.1.

The size of this patch depends on the wavelength and thus the microstrip patch antenna is classified as a resonant antenna. As with all resonant antennas, the bandwidth is narrow, usually only a few percent.

![Fig. 1.1 basic structure of microstrip patch](image)

1.2 GENERAL OVERVIEW OF MICROSTRIP PATCH

Microstrip antennas evolved more slowly than their circuit counterparts but have played an increasingly significant role in the antenna field since the mid-1970s, the microstrip patch antenna technology was well established in terms of design and modeling techniques. This is credited to several of its inherent characteristics like being low profile lightweight and inexpensive. More than twenty years after the first developments, research in the field is quite active, and microstrip technology will most likely remain at the forefront of antenna technology for a long time.
reduce the size, weight and cost of components and systems for low signal level application by replacing the more cumbersome waveguide components and assemblies.

A microstrip patch Antenna uses the "MICROSTRIP" structure to construct an antenna, Microwave engineers first uses “STRIPLINES" to fabricate circuits. The strip line requires two ground planes, and a flat strip in between, to guide signals. As the art progresses, many circuits are found to be easily made with "Microstrip" structure, which is similar to the strip line, but with one ground plane removed.

One of the big problems with certain circuits implemented in microstrip is radiation. Fortunately, antenna engineers picked up on this undesirable effect and started the microstrip technique, although it is a resonant device with relatively narrows operation bandwidth. Microstrip antennas have been one of the most innovative topics in antenna theory and design in recent years and are increasingly finding application in a wide range of modern microwave systems. A microstrip antenna in its simplest configuration consist of a very thin (t << λ₀ where λ₀ is the free space wavelength) metallic strip (patch) placed a small fraction of a wavelength (h << λ₀, usually 0.003 λ₀ ≤ h ≤ 0.05 λ₀) above a conducting ground plane. A dielectric sheet (referred to as the SUBSTRATE) separates the patch and the ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch. The patch conductor as normally copper and can assume virtually any shape but generally simple geometries are used and this simplifies the analysis and performance prediction. The patches are usually photo etched on the dielectric substrate.

1.3 BASIC CHARACTERISTICS OF MICROSTRIP ANTENNA

The basic microstrip patch antenna is made up of a thin sheet of low loss insulating material called dielectric substrate (Fig. 1.1). It is considered the mechanical backbone of the microstrip circuit as it provide a stable support for the conductor strips and patches that make up connecting lines, resonators and antennas. Furthermore, it fulfills an electrical function by concentrating the electromagnetic fields and preventing unwanted radiation in circuits. The electrical characteristics of the antenna and preventing unwanted radiation in circuits, the electrical characterizes of the antenna are also largely determined by its permittivity and
thickness. The bottom layer of the dielectric is completely covered with metal and this is known as the ground plane. The topside of the dielectric is partly moralized of circuit pattern can be printed. The radiating patch element of the pattern may take any form for example square, rectangle, circular, triangular, ring etc. The principle planes are shown in fig 1.2 for a rectangular patch.

Low profile antennas may be required in high performance aircraft, spacecraft, land vehicles, satellite and missile application where size, weight cost performance, ease of installation and aerodynamic profile are constraints. In order to meet all these requirements, these microstrip antennas are manipulated because of their inherent characteristics;

i) Capability of adopting modern printed-circuit technology

ii) Compatible with modular design

iii) Attractive features

**Fig. 1.2 planes of microstrip patch**

**Fig 1.3 antenna structure with coaxial feeding**

1.4 PRINCIPLE OF OPERATION:
Microstrip antennas are suitable shaped discontinuities that are designed to radiate. The discontinuities represent abrupt changes in the microstrip line geometry e.g. a step change in width, an open end and a microstrip bend. Discontinuities alter the electric and magnetic fields distributions. These results in energy storage and sometimes radiation at the discontinuity. As long as the physical dimensions and the relative dielectric constant of the line remain constant, virtually no radiation occurs. But the discontinuity introduced by the rapid change in the line at the junction between the feed line and patches radiated. The other end of the patch where the metallization abruptly ends also radiated. When the fields on the microstrip line encounter and abrupt change in width at the input of the patch, electric field spreads out. It creates fringing fields at this edge. After this transition the patch looks like another microstrip line. The field propagates down this line until the other edge is reached. Here the abrupt ending of the transmission line again creates the fringing fields as for the open end discontinuity. The fringing field store energy. The edges appear as the capacitors to ground since the changes in the electric field are greater than that of the magnetic field. The fringing field radiate, which is represented by a conductance in shunt with the edge capacitance, which accounts for the power lost due to radiation. The radiation mechanism, fringing fields and the equivalent circuits are shown in Fig.1.4 and Fig.1.5.
These antennas are very thin and rugged and can be easily mounted practically on any metallic body. The radiating elements of patch conductors, normally of copper or gold, can assume any shape. The microstrip antennas have several additional advantages and of course certain disadvantages too which are discussed in the subsequent sections.

1.5 DESIGN PROCEDURE OF RECTANGULAR PATCH ANTENNA:

There are several theories that can be used to analyzed and design of microstrip patch antenna like transmission line model, cavity model etc. In the present design transmission line model is used. According to this model a rectangular patch of length $L$ and width $W$ can be viewed as a very wide transmission line that is transversely resonating, with the electric field is varying sinusoidal under the patch along its resonant length $L$. The electric field is assumed to be invariant along the width $W$ of the patch. Furthermore, it is assumed that the antenna’s radiation comes from the fields leaking out the width, or radiating edges of the antenna. Consider a rectangular patch of width $W$ and length $L$ over grounded substrates with the thickness $h$ and relative permittivity $\varepsilon_r$.

(a) For efficient radiator, a practical width that leads to good radiation efficiencies for fundamental TM$_{10}$ mode is –
\[
W = \frac{C}{2f \left[ (\varepsilon_r + 1)/2 \right]^{1/2}}
\]

(b) Since some of the wave travel in the substrate and some in the air, an effective dielectric constant \( \varepsilon_{\text{reff}} \) is introduced to account for fringing and the wave propagation in the line and is given by

\[
\varepsilon_{\text{reff}} = \frac{(\varepsilon_r + 1)/2 + ((\varepsilon_r - 1)/2) (1 + 12h/W)^{1/2}}{\varepsilon_{\text{reff}} - 0.258 (W/h) + 0.8}
\]

(c) It can be seen that the fields slightly overlap the edges of the patch making the electrical length of the patch slightly larger than its physical length. Thus a correction term \( \Delta L \) also called edge extension is introduced in account for the fringe capacitance. This edge extension \( \Delta L \) is given by

\[
\Delta L = 0.412 h \left[ \frac{\varepsilon_{\text{reff}} + 0.300}{\varepsilon_{\text{reff}} - 0.258} \right] (W/h) + 0.264
\]

(d) Because of the fringing effect, the dimension of the patch along its length have been extended on each end by a distance \( L \), so the effective length of the patch is given by

\[
L_{\text{eff}} = L + 2\Delta L
\]

(e) The actual length of patch \( L \) is given by \( L = L_{\text{eff}} - 2\Delta L \)

1.6 ADVANTAGES AND DISADVANTAGES OF MICROSTRIP ANTENNAS:
Microstrip antennas have several advantages as compared to conventional microwave antennas and therefore many applications over the broad frequency range from 100 MHz to 50 GHz. Some principal advantages of microstrip antennas compared to conventional microwave antennas are as follows:

1.6.1 ADVANTAGES:

- Easily mountable on missiles, rockets and satellites without major alterations.
- Low scattering cross section.
- Structure is planar in configuration and enjoys all the advantages of printed circuit technology.
- Linear and circular polarization are possible with simple changes in feed position
- Dual frequency antennas can be made easily.
- No cavity backing is required.
- Compatible with modular designs as solid state devices such as oscillators, amplifiers, variable attenuators, switches, modulators, mixers, phase shifters etc. can be added directly to the antenna substrate board.
- Feed lines and matching networks are fabricated simultaneously with the antenna structure.

1.6.2 DISADVANTAGES:

As compared to conventional microwave antennas microstrip antennas have some disadvantage also such as:

- Narrow bandwidth with a few percent.
- Lower gain due to loss.
- Most of the Microstrip antennas radiate into the half plane.
- Practical limitations on the maximum gain ($\approx 20$dB).
- Poor end fire radiation performance.
- Poor isolation between the feed and the radiating elements.
- Possibility of excitation of surface waves.
- Lower power handling capability.

However there are ways to substantially diminish the effect of some of these disadvantages. For example, surface wave excitation may be suppressed or eliminated by exercising care.
during design and fabrication.

1.7 APPLICATIONS OF MICROSTRIP PATCH ANTENNA:

For many practical designs, the advantages of microstrip antennas far outweigh their disadvantages. Some notable system applications for which microstrip antennas have been developed include as here under:

- **SATELLITE COMMUNICATION**: - Domestic DBS receiver, Vehicle-based antenna, switched beam array and satellite navigation receiver
- **AIRCRAFT ANTENNAS**: - communication and navigation altimeters, blind landing system
- **MISSILES AND TELEMETRY**: - Stick on sensors, proximity fuses, millimeter devices.
- **MISSILE GUIDANCE**: - Seeker monopoles arrays, integrated roadmen Arrays.
- **ADAPTIVE ARRAYS**: - Multi target acquisition, semiconductor integrated arrays.
- **MOBILE RADIO**: - Pagers and hand telephones, Man pack systems.
- **BIOMEDICAL RADIATOR**: - Application in microwave cancer therapy.
- **BATTLEFIELD COMMUNICATIONS AND SURVEILLANCE**: - Flush Mounted on vehicles
- Doppler and other radars
- Command and control
- Environmental instrumentation and remote sensing
- Feed elements in complex antennas

With the increase in the awareness of the possibilities of Microstrip antenna, 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.