SMART DIRECTIONAL ANTENNA

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Abstract— **In the recent years the development in communication systems requires the development of low cost, minimal weight and low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. This technological trend has focused much effort into the design of a microstrip patch antenna. Micro strip patch antenna has attracted wide interest due to its important properties such as light weight, low profile, simple to fabricate and easy to integrate with RF devices. Therefore, method of moments based IE3D software is used to design a Microstrip Patch Antenna with enhanced gain, bandwidth and high directivity. In this paper we have compared various technique to get high directivity of microstrip antenna on IE3D software. The different method which we used are**

- **Improving Microstrip Patch Antenna Directivity using EBG Superstrate**
- **Enhancement of Directivity of Rectangular Micro Strip Antenna Using Multilayer Multidielectric Structure**
- **Directivity Enhancement of Microstrip Patch Antennas Using dielectric Superstrate**

Keyword: **micro strip patch antenna, IE3D software, directivity,simulation.**

I. INTRODUCTION

Microstrip antenna: In its most fundamental form, a Micro strip patch antenna (MPA) 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 1.4. 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

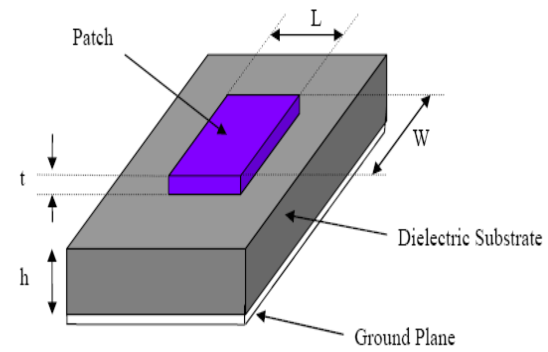

Fig.1: Structure of a microstrip patch antenna

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape as shown in Figure1 . For a rectangular patch, the length L of the patch is usually $0.3333\lambda o < L < 0.5\ \lambda o$, where λo is the free-space wavelength. The patch is selected to be very thin such that $t << \lambda o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$. The dielectric constant of the substrate (εr) is typically in the range $2.2 \leq \varepsilon r \leq 12$.

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. However, such a configuration leads to a larger antenna size. In order to design a compact microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a trade-off must be realized between the antenna dimensions and antenna performance.

Directivity

The Directivity *D*, of an antenna is the maximum value of its *directive gain*. Directive gain is represented as $D(\theta,\phi)$, and compares the radiation intensity (power per unit solid angle) $U(\theta,\phi)$ that an antenna creates in a particular direction against the average value over all directions:

$$D(\theta,\phi)=\frac{U(\theta,\phi)}{P_{\rm tot}/(4\pi)}$$

Here θ and ϕ are the standard spherical coordinate angles, $U(\theta,\phi)$ is the radiation intensity, which is the power density per unit solid angle, and $P_{\rm tot}$ is the total radiated power

II. Literature Review

A. Simulation software

IE3D is an integral equation and method of moment based EM simulator. IE3D mainly focuses on general planar and 3D metallic structures in layered dielectric environments. It is very efficient, accurate and flexible for such structures.IE3D can also model 3D dielectric structures such as patch antennas with finite substrates and dielectric resonator antennas. The software used to perform all simulations is Zealand Inc's IE3D. IE3D is a full-wave electromagnetic simulator based on the method of moments. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculate and plot the *S* parameters, VSWR, current distributions as well as the radiation patterns. Some of IE3D's features are

1 Can model true 3D metallic structures in multiple dielectric layers in open, closed or periodic boundary

2 High efficiency, high accuracy and low cost electromagnetic simulation tool on PCs with windows based graphic interface

3 Automatic generation of non-uniform mesh with rectangular and triangular cells

4 Can model structures with finite ground planes and differential feed structures

5 Accurate modeling of true 3D metallic structures and metal thickness

6 Efficient matrix solvers

7 3D and 2D display of current distribution, radiation patterns and near field.

B. Comparison of methods:

1) . Improving Microstrip Patch Antenna Directivity Using EBG Substrate:

There are several configurations of EBG structures according to their application in antenna. Two main configurations are:

a. EBG structures place on antenna substrate that by creation band gap in certain frequency range Suppress from propagation of surface wave. This configuration is defined as EBG substrate. In this configuration both of mushroom-like EBG and uniplanar EBG is used.

b. EBG structure place at certain distance above radiation source of antenna i.e. patch and by creation ultrarefraction phenomenon, concentrate radiation in various direction normal to EBG structure. This configuration is defined as EBG superstrate or Metamaterial superstrate and only the uniplanar EBG is used in this one.

To obtain an optimum response for directivity the air gap between the superstrate and the ground plane was varied to produce the final characteristic of directivity. A maximum directivity of 11.78 dB is obtained at the frequency of 7GHz. Therefore, it is important to control the air gap thickness in order to obtain a better performance from the antenna.

2) Enhancement of Directivity of Rectangular Micro Strip Antenna Using Multilayer Multidielectric Structure:

The directivity of microstrip patch antenna is enhanced by using covered dielectric layer which is separated from feed patch by air as an another dielectric. Here two patches, one feed patch and one parasitic patch are used to enhance the directivity and bandwidth and whole structure resonates at their resultant frequency which is in the ISM band. Air is used as dielectric between feed patch and ground plane as well as between feed patch and parasitic patch. The dimensions of feed patch are adjusted to achieve desired resonant frequency. In this microstrip antenna the coaxial probe feed technique is used for its simplicity. This work leads to conclusion that directivity, bandwidth and gain of microstrip antenna can be increased by covered dielectric and multidielectric structure with parasitic patch. The results show that the directivity is enhanced by 56% as compared to conventional rectangular patch antenna. It is observed that this patch antenna has directivity of 14 dB which is higher than normal patch antenna. This patch antenna resonates at 5.8GHz which is in ISM band. Air gap between ground and feed patch helps to increase gain.

3) Directivity Enhancement of Microstrip Patch Antennas Using Dielectric Superstrate:

The MPA covered by a planar Dielectric Superstrate structure, which operates at 6GHz. The parameters of this MPA/DS composite are presented. The variation of the directivity as well as of S11 with frequency is shown respectively. Comparison of performance of the MPA with and without the DS. The results show that directivity of patch with a planar DS can reach 13.92dB at 6GHz, which is 7dB above that of the MPA without a superstrate

III. System and Design

Enhancement of Directivity of Rectangular Micro Strip Antenna Using Multilayer Multidielectric Structure:

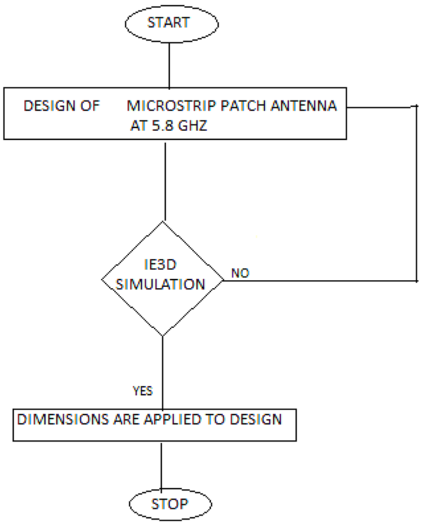

Fig.4:flow diagram

IV. Proposed Methodology

Proposed structure: The dimensions of this MSA are designed for the resonant frequency of 5.8GHz. The feed patch is set at 2mm height above ground plane and parasitic patch at height of λ/2 above feed patch. The FR4 substrate is on parasitic patch with thickness of 1.6mm. Air is used as dielectric between ground plane and feed patch as well as between feed patch and parasitic patch. This is also called as space fed MSA Top parasitic patch is mounted using foam material which is having dielectric constant equal to air and

Choice of Substrate**:** Choosing a substrate is as crucial as the design itself. The substrate itself is part of the antenna and contributes significantly to its radiative properties. Many different factors are considered in choosing a substrate such as dielectric constant, thickness, stiffness as well as loss tangent. The dielectric constant should be as low as possible to encourage fringing and hence radiation. A thicker substrate should also be chosen since it increases the impedance bandwidth. However, using a thick substrate would incur a loss in accuracy since most microstrip antenna models use a thin substrate approximation in the analysis. Substrates which are lossy at higher frequencies should not be used for obvious reasons. The choice of a stiff or soft board basically depends on the application at hand. In this paper FR4 is selected as the dielectric material having dielectric constant as 1.

Input Impedance Matching**:** Impedance matching is critical in microstrip antennas since the bandwidth of the antenna depends upon it. Besides this, a poor match results in lower efficiency also. Line fed rectangular patches may be fed from the radiating or the non-radiating edge. To find an impedance match along the non-radiating edge we may use the Transmission Line Model. The input impedance along the non-radiating edge is lowest at the center since two equally high impedances at the two ends are transformed into a low value at the center and connected in parallel.

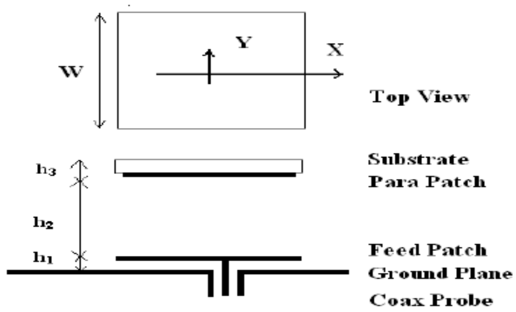

Fig.3 Space Fed MSA

Coaxial probe feed technique is used for its ease of feed. Top substrate is FR4 material acts as protective cover to parasitic patch. Air acts as low dielectric material which helps to increase directivity. Parasitic patch is kept at λ/2 height from the feed patch. The patch dimensions are designed using basic patch antenna design

Table 1: Parameters of multidielectric microstrip patch antenna (f_0=5.8GHz)

S.No.	Layer Geometry	Dimensions
1	Top substrate	ε_{r3}=4.4, h_3=2
2	parasitic patch	W_p=24mm, L_p=14mm
3	Air gap 2	ε_{r2}=1 h_2=26mm
4	Feed patch	W_F=24mm L_F=22mm
5	Air gap 1	ε_{r1}=1 h_1=2mm
6	Ground plane	Aluminum
7	Feed	50Ω ,SMA probe X_f=2.8mm Y_f=0mm

A. Advantages of micro strip antenna

Some of their principal advantages of microstrip patch antennas 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 (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

B. Limitation of Microstrip Antennas

Some of their major limitations 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

C. Applications of Microstrip Antennas

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

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