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Design of Multilayer Microstrip Patch Antenna for Satellite Application

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ABSTRACT: The research on antenna for application has received much growing attention in recent years. Some efforts have been made to achieve wide bandwidth, such as using the stacked multilayer, spiral antennas, planar inverted-F antennas (PIFAs), slot antennas, dipoles and loop antennas, or adopting coplanar waveguide (CPW) feeding. In this research, Multilayer structure is considered to analyze various parameters at different environmental conditions to generate better wave radiation. This paper proposes a new model called multilayer structure patch antenna (MSPA). The equivalent model is developed based on existing literature and analysed in detail to obtain wideband and multi-band characteristics. For wideband MSPAs, the theoretical maximum bandwidth is derived under VSWR criterion. It is proposed to study and validate to optimize the impedance characteristics obtained by the MSPA model is compared with other wave electromagnetic simulations and measurements. The proposed antenna is optimized using CST microwave studio.

KEYWORDS:Microstrip patch antenna(MSPA), Multi layer, Satellite Application.

I. INTRODUCTION

Antenna is a device which can radiate or receive electromagnetic waves. An antenna can be classified as transmitting and receiving. It is also identified that the same antenna can be used for transmission and reception of electromagnetic waves. The important property of an antenna is the ability to focus and shape the radiated power in space. The present communication scenario uses microwave frequencies for efficient transmission and reception. The term microwave is used for the radiations with frequencies 1GHz to 300GHz [1]. The rapid development of microstrip antenna technology began in the late 1970s. By the early 1980s basic microstrip antenna elements and arrays were fairly well established in terms of design and modeling, and workers were turning their attentions to improving antenna performance features (e.g. bandwidth), and to the increased application of the technology. Microstrip patch antenna (MPA) is one of the types of microwave antennas.

At the present time, the role of microstrip antennas in modern telecommunications and radio-Electronic systems has become huge. Due to many advantages of these structures, this antenna is used in wide variety of applications. In order to reduce the stray field of microstrip lines and reduce its geometrical dimensions, one should use the material with maximum electrical permeability. The major problem of microstrip antenna is its narrow bandwidth. To achieve broader bandwidth performance the multi-layer microstrip patch antenna structure can be used [2]. Microstrip antenna consists of a metal conducting patch on the top side and, can be printed on a thin grounded dielectric surface called substrate. In the simplest cases, a Single radiating element can be power supplied via the coaxial line, microstrip line, or via electro-magnetic coupling. Much more interesting and practical way of powering of the multi-layer antenna is slotted power presented in Figure 2.

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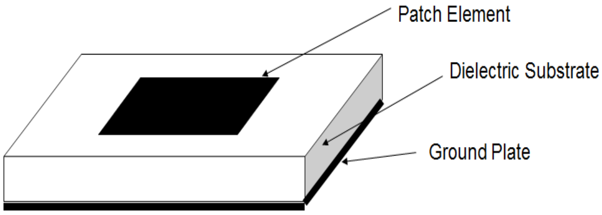

Fig 1. Basic Microstrip Patch Antenna

An example antenna made in multilayer technology can be constructed as follows. The radiating Element is a rectangular patch etched on the underside of the upper layer of the laminate and Stimulated through the slot cut in the shield covering the upper side of the lower layer of the Laminate. The slot can be powered by asymmetrical strip line or concentric lines. This type of antennas has the following characteristics: parameters of the laminate used to build the antenna and the power line can be chosen optimally, it is possible to achieve very low levels of unwanted radiation, the need of precise composing of the package, difficult theoretical analysis, and large possibilities of adjustment of the impedance [4]. It can be concluded that, for both classic and multi-layer antennas, the presence of the dielectric has an impact on the reduction of the dimensions of the radiating element in comparison to the option without the dielectric. One of the major disadvantages of classic strip antennas is their relatively low energy efficiency. This is mostly due to losses in the dielectric. However, in multi-layer antenna, the radiated electromagnetic wave in a large part is formed not in the dielectric but in the free space. So we can expect smaller losses.

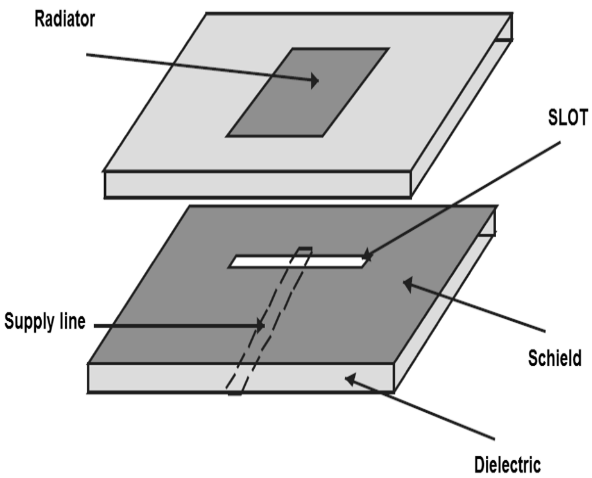

Fig 2. Micro strip patch antenna is designed by using different substrates

Antennas which are used for these applications should be of low profile, light weight, low volume. All these requirements are overcome by using Micro strip antennas. The structure of patch antenna consists of dielectric substrate on optically planar ground plane, radiating element on other side of substrate which is prepared with conducting materials [1]. Microstrip antennas are used in a wide range of applications [1], but due to its narrow impedance bandwidth restriction occurs. The microstrip antenna generally consists of a radiating element (patch), an intermediate dielectric layer, and a ground plane [5].

The radiating element or patch is generally made of conducting material such as copper or gold and can take any possible shape like rectangular, square, circular, elliptical, triangular etc [2].The straight-forward approach to improving bandwidth is increasing the thickness of the substrate supporting the microstrip patch. We can go with multilayer microstrip proximity coupled antenna for improving the bandwidth. To enhance the bandwidth and

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directivity of Microstrip antennas we are in need of microstrip array antenna because a single antenna generates an unacceptable bandwidth, efficiency and directivity.

In this paper the focus is on bandwidth enhancement technique of a multilayer patch antenna for Satellite applications. In order to enhance the bandwidth, antenna losses are contained by controlling those quality factors Which can have a significant impact on the bandwidth for a given permittivity and thickness of the substrate. This has been achieved by conformal transformation of the multidielectricmicrostrip antenna. For the ease of analysis Transient method is used to map the complex permittivity of a multilayer substrate to a single layer.

II. FEEDING AND DESIGN

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. 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).

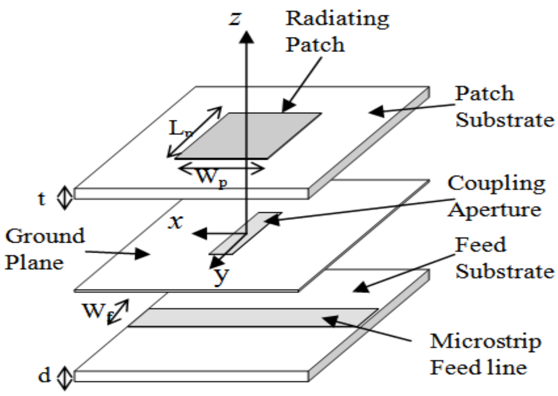

Fig 3. Aperture Coupled feed technique

In this type Aperture coupled feed technique is used. In this technique the radiating patch and the microstrip feed line are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.The aperture coupled feeding technique for [9] micro strip antenna was first proposed by D.M. Pozar [2] in 1985. This feed technique posses several advantages over other feeding methods. In the aperture coupling feed technique the two dielectric substrates are separated by a ground plane. The bottom side of the lower substrate contains of microstrip feed line which is connected to the radiating patch through the slot in the ground plane. Typically a high dielectric material is used for the bottom substrate, and thick low dielectric material for the top substrate [3]. Aperture coupling [6] also convenient to fabricate the antenna using two or more dielectric layers and, it is necessary to determine the resonant frequency which depends on the layers used in antenna [4].These antennas are more advantageous in arrays because they are electrically isolates, the feed & phase shifting circuitry from the patch antennas. But micro strip antennas are band limited [6] which is a serious drawback of micro strip antenna. Basically micro strip antenna has three design parameters; these are substrate's Dielectric constant (ε_r), its operating frequency (f_0) and height of substrate (h) from ground plane [3], which affects the dimensions of patch, radiation pattern, return loss & other parameter ofmicro strip antenna.

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B.Design of Multi layer MSPA

This paper has presented for increasing the bandwidth and directivity and so multilayer proximity coupled antenna is used. Using this technique it is also improved the directivity of antenna which is highly desirable for Satellite application.

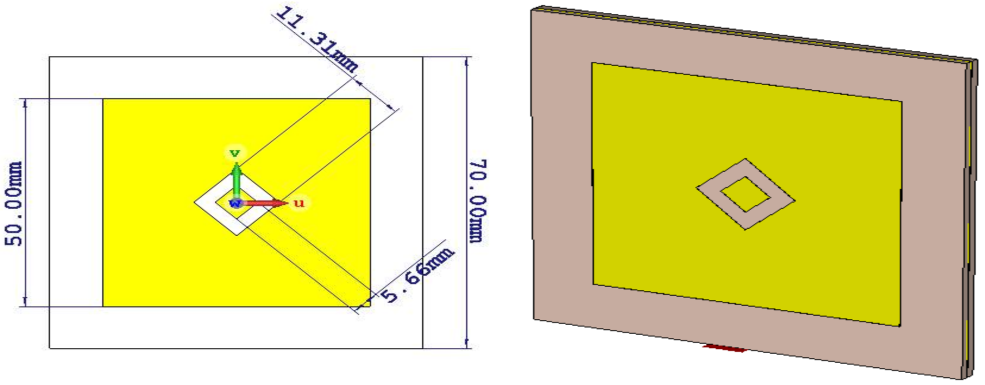

Fig 4. Proposed structure of multilayer Antenna

Design of the proposed antenna consists of circular slot in the ground plane with multilayer structure. The dielectric material of FR-4 Epoxy with 1.6 mm thickness is selected for this design and has a dielectric constant of 4.4(εr) and loss tangent equal to 0.002. Low dielectric constant is used in the prototype design because it gives better efficiency and higher bandwidth and it increases the fringing field at the patch periphery and thus increases the radiated power. The small loss tangent was neglected in the simulation. Substrate thickness is another important design parameter. periphery like low dielectric constant and thus increases the radiated power. The Proposed antenna is simulated using CST Microwave studio and the simulated results are obtained. The design parameters for the proposed antenna are listed as below.

TABLE I. DESIGN CONSIDERATIONS

Layer Geometry	Dimensions
Bottom Substrate(FR-4)	70mm
Top Substrate(FR-4)	70mm
Ground Plane(copper)	70mm
Patch(copper)	50mm
Feed(thickness)	0.035mm

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 loose 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 FR-4 is selected as the dielectric material having dielectric constant as 1.

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III. SIMULATION AND ANALYSIS

In this project, a rectangular multilayer microstrip patch antenna is considered to design a lightweight, low volume and low profile antenna for Satellite application, at a frequency range of 3GHz to 8GHz.

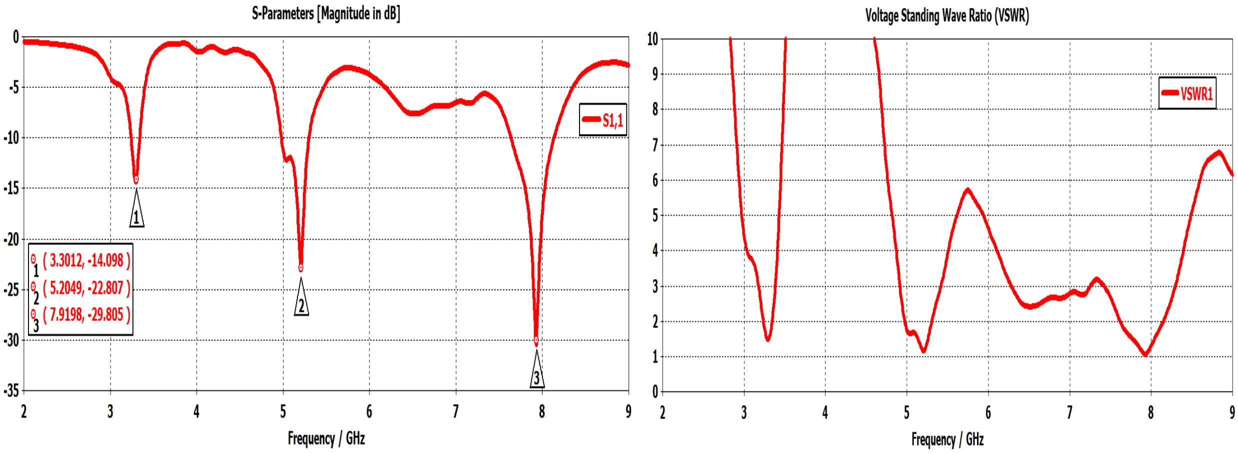

Fig 5. Return loss and Voltage Standing Wave Ratio plot of proposed structure.

Initially the multilayer MSPA design and simulation results are not fair enough to apply for the desired applications. A simple design procedure based on previous literature and theoretical analyses is used to formulate the model. While the design rules presented here are optimized and can be fabricated for complete testing to validate at all situations, it does provide a good starting point for antenna designers as it gives better and timelier results than simply through guesses or cut-and-try techniques. Hence, using this set of calculation, an optimum multilayer microstrip patch antenna is designed with a desired bandwidth, operating from 3GHz to 8GHz. This operating frequency range is close to the Satellite communication.

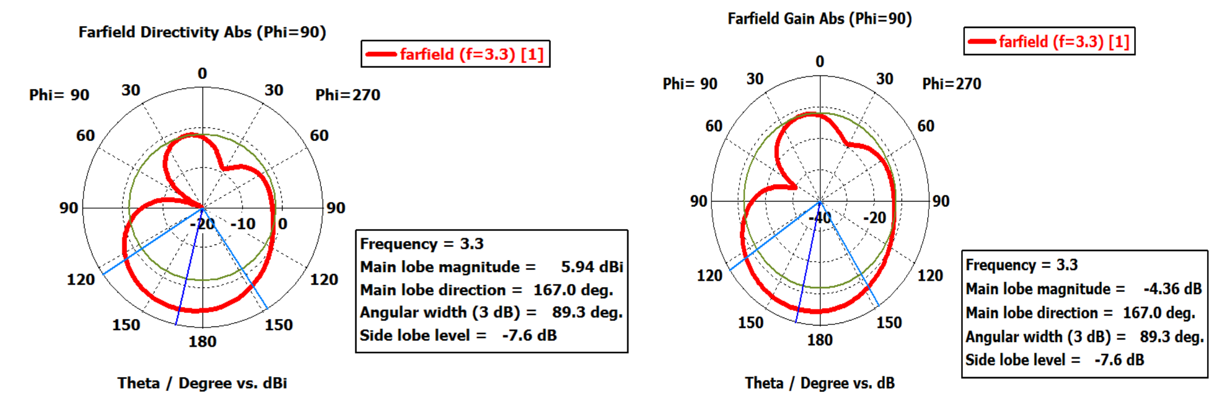

Fig 6. Directivity and Gain plot of proposed design

IV. CONCLUSION AND FUTURE SCOPE

The design of multilayer MSPA has been completed using CST software. The simulation results are good enough to satisfy our requirements to fabricate it on hardware which can be used wherever needed. The proposed design reveals

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the possibility to use in Satellite applications. In addition, the development and simulation depict consideration of multi layers in MSPA to improve the application range from mobile applications to satellite and aerospace applications. From the results it is concluded that the bandwidth and gain of the antenna can be improved by using other elements along with multilayer stacked configuration. A further study can be look into the design of a Multilayer MSPA operating at various frequencies. This will further improved the antenna with very directive characteristics or very high gains to meet the demands for different distance communication. These design considerations such as gap can be considered by designers to improve a wide variety of structures to meet the often conflicting needs for different applications. And also changing of feed with recent techniques, consideration of optimizing modes can be introduced.

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