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Design of Elliptical Slotted Microstrip Patch Antenna for Mobile Communications

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Abstract:- **the microstrip antennas, due to their great advantages, have increasingly wide range of applications in wireless communication systems as handheld mobile services, satellite communication systems, and biomedical applications. A rectangular microstrip patch antenna with elliptical slot is designed here for simulation and developed to examine the Ultra High Frequency (UHF) applications. The design and simulation have been done by Computer Simulation Technique (CST) Microwave Studio tool and further the fabrication is tested for analyzing the simulation results. The proposed design reveals the possibility of having slotted shapes in rectangular patch antenna for UHF – Mobile applications. In addition, the development and simulation depict consideration of slots in arrays of rectangular patch antenna to improve the application range from mobile applications to satellite and aerospace applications. These design considerations have led antenna designers to consider a wide variety of structures to meet the often conflicting needs for different applications. There is further scope for this concept by designing and implementing an array of such patch antennas as a substitute for traditional methods.**

Keywords:— **Microstrip patch antenna(MSPA), Mobile Communication, Ultra High Frequency and Simulation**

I. INTRODUCTION

The IEEE definition of an antenna as given by Stutzman and Thiele is, "That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves". An antenna is defined as a device for the radiation and reception of the electromagnetic waves. An antenna is of paramount importance in any communication system. It acts as a transducer (transitional structure) between the transmission line and the free space. An important property of an antenna is the ability to focus and shape the radiated power in space. It enhances the power in some wanted directions and suppresses the power in other directions. The present communication scenario uses microwave frequencies for efficient transmission and reception. The term microwave is used for the radiations with frequencies 1 to 300GHz. However, microwave really indicates the wavelengths are in the micron ranges. This means microwave frequencies are up to infrared and visible light regions. In this region microwave frequencies refer to those from 1 to 106 GHz. The antennas used in such microwave systems are called microwave antennas. The concept of microstrip antenna dates back to the 1950's, but it was not until the 1970's that greater emphasis was given to develop this technology. 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. This is mainly due to the availability of good substrates. Since then, extensive research and development of microstrip antenna and arrays, exploiting the numerous advantages such as light weight, low volume, low cost, planar configuration, compatibility with integrated circuits, have led to diversified applications and to the establishment of the topic as a separate entity within the broad field of microwave antennas.

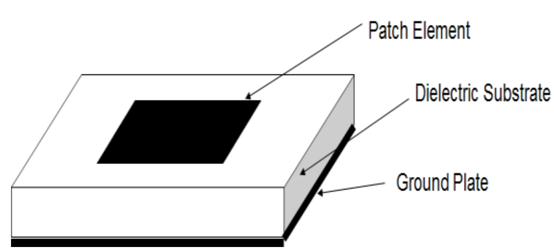

Fig. 1. Basic Microstrip Patch Antenna

A microstrip or patch antenna is a low profile antenna that has a number of advantages over other antennas it is lightweight, inexpensive, and easy to integrate with accompanying electronics. While the antenna can be 3D in structure (wrapped around an object, for example), the elements are usually flat; Hence their other name, planar antennas. Note that a planar antenna is not always a patch antenna. The following drawing shows a patch antenna in its basic form: a flat plate over a ground plane (usually a PC board). The center conductor of a coax serves as the feed probe to couple electromagnetic energy in and/or out of the patch. The electric field distribution of a rectangular patch excited in its fundamental mode is also indicated. The electric field is zero at the center of the patch, maximum (positive) at one side, and minimum (negative) on the opposite side. It should be mentioned that the minimum and maximum continuously change side according to the instantaneous phase of the applied signal. The electric field does not stop abruptly at the patch's periphery as in a cavity; Rather, the fields extend the outer periphery to some degree. These field extensions are known as fringing fields and cause the patch to radiate. Some popular analytic modeling techniques for patch antennas are based on this leaky cavity concept.

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 Figure 1.3. For a rectangular patch, the length L of the patch is usually $0.3333\lambda 0 < L < 0.5\ \lambda 0$, where $\lambda 0$ is the free-space wavelength. The patch is selected to be very thin such that $t << \lambda 0$ (where t is the patch thickness).The height h of the dielectric substrate is usually $.003\ \lambda 0 \leq h \leq 0.05\ \lambda 0$. The dielectric constant of the substrate (εr) is typically in the range $2.2 \leq \varepsilon r \leq 12$. The microstrip antenna approach has become rather popular and widely used because of the fact that they can be easily fabricated by photolithographic processes. This idea is similar to printed circuits operating at high microwave frequency in terms of GHz as compared to a simple printed circuit board for electronics at low frequency. Microstrip feed lines and radiating patch elements can thus be photo etched with ease on the dielectric substrate.

One of the most prominent communication systems that will utilize the microstrip antenna is the mobile satellite system. The current terrestrial system cannot provide complete coverage within a large global system, such as the United States. As a result, mobile-to-mobile to communication would not be available in the rural area where no cellular station exists. A satellite-based system can fulfill this need by using either a few sets of fixed geostationary satellites or a large number of low earth orbiting satellites. Two examples of the geostationary satellite systems are, the already implemented international Maritime Satellite System (INMARSAT) & the developing Mobile Satellite System (MSAT). These use several different versions of earth terminals. However the recently developed standard-M terminal, which is intended for land application, uses briefcase size microstrip array antennae. This antenna uses six cellular patches and provides 14.5db of gain.

Low earth orbiting satellite systems, such as the L-Band IRIDIUM system, proposed by Motorola would require multiple high gain microstrip phased arrays on each satellite and low gain omni directional antennas on the ground terminals. Each of the satellite's phased arrays has hundreds of Microstrip patches. By printing all of these patches on a single flat panel, the fabrication process will lead to lower cost and the antennae system will require less volume and contribute less mass on the satellite. The microstrip patch can be certainly used if the conformability to the vehicles roof is required.

II. FEEDING AND DESIGN

A. Feed Technique

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).

In this type Line 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 planar structure. 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

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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.

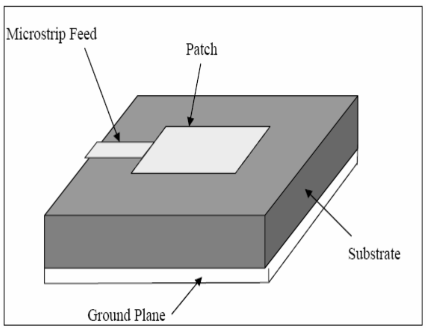

Fig. 2. Microstrip patch antenna with Line Feed

B. Design of Elliptical Slotted MSPA

The position, shape and orientation of the slots will determine how (or if) they radiate. In addition, the shape of the waveguide and frequency of operation will play a major role. To understand what is going on, we'll need to understand the fields within the waveguide first.

Slotted antennas used with waveguides are a popular antenna in navigation, radar and other high-frequency systems. They are simple to fabricate, have low-loss (high efficiency) and radiate linear polarization with low cross-polarization. These antennas are often used in aircraft applications because they can be made to conform to the surface on which they are mounted. Slotted waveguides are often used because they are capable of transmitting high power levels.

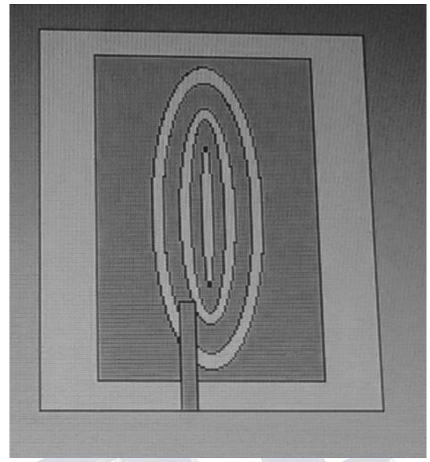

Fig. 3. Proposed Elliptical Slotted MSPA

The present design having elliptical slots has been created in CST Microwave Studio for the resonant frequency 5.2 GHz, antenna simulation tool. The geometry of the proposed model is as given in the fig. The dimensions and feed point location for proposed antenna have been optimized to get the best possible impedance match to the antenna.

TABLE I. DESIGN CONSIDERATIONS

Parameters	Values/Comments
Ground Material	Copper
Substrate Material	FR-4
Patch	Copper
Frequency	1 to 3

III. SIMULATION AND ANALYSIS

In this project, a rectangular microstrip patch antenna was selected to design a lightweight, low volume and low profile planar antenna in the application for a mobile communication system (UHF), at a frequency range of 1.66 GHz to 2.185 GHz. Initially the rectangular patch antenna design and simulation results are not fair enough to apply for the desired applications. Then, elliptical slot has been introduced with dimensional changes to attain the frequency level using CST software. A simple design procedure based on previous literature and theoretical analyses is used to formulate the model. While the design rules presented here are approximate and may not work in

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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 Elliptical-slot microstrip patch antenna is designed with a desired bandwidth, operating from 1.66 GHz to 2.185 GHz. This operating frequency range is approximately closed to the Mobile communication UHF, which operates from 1250 MHz – 3000 MHz The proposed design reveals the possibility of having slotted shapes in rectangular patch antenna for UHF – Mobile communications.

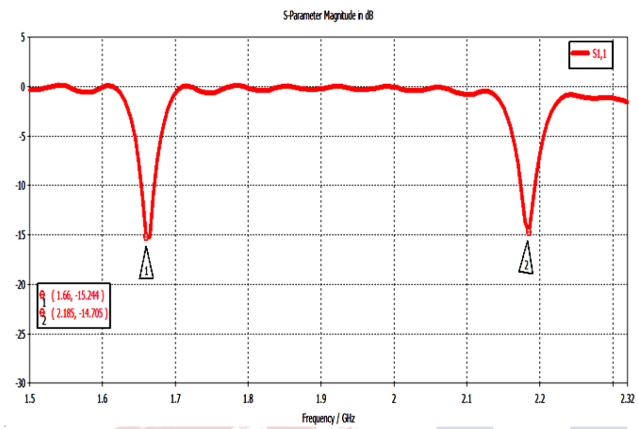

Fig. 1. Return Loss of the Proposed antenna at 1.66GHz and 2.19GHz

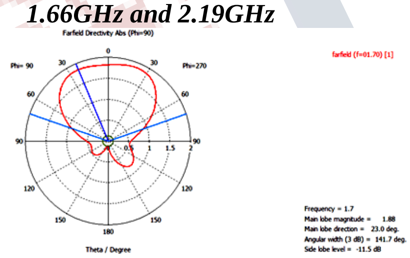

Fig. 2. Directivity of the Proposed antenna at 1.7GHz

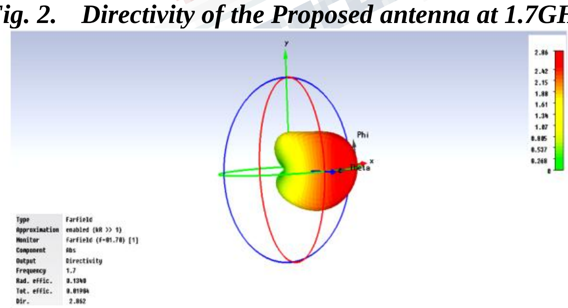

Fig. 3. Directivity of the Proposed Antenna at 1.7GHz

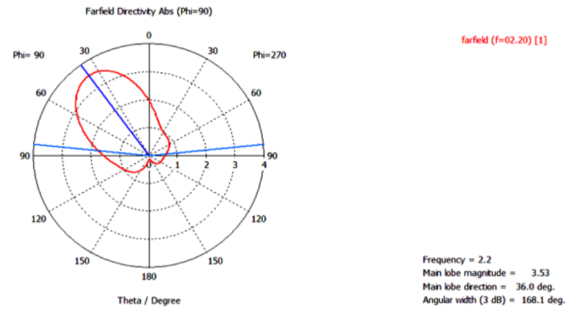

Fig. 4. Directivity of the Proposed antenna at 2.2GHz

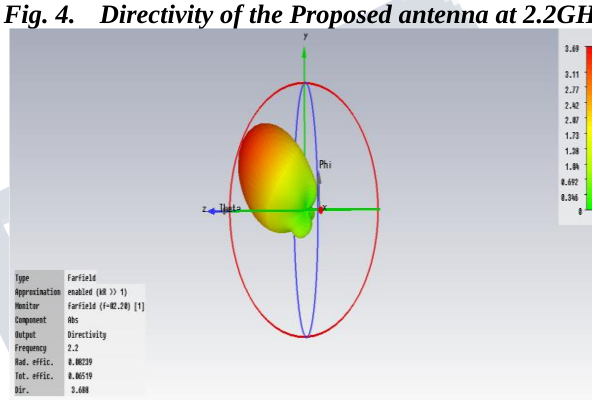

Fig. 5. Directivity of the Proposed Antenna at 2.2GHz

IV. CONCLUSION AND FUTURE SCOPE

The design of elliptical slotted rectangular patch antenna 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 the possibility of having slotted shapes in rectangular patch antenna for UHF – Mobile applications. The fabrication and test results support the simulation results. In addition, the development and simulation depict consideration of slots in arrays of rectangular patch antenna to improve the application range from mobile applications to satellite and aerospace applications.

A further study can be look into the design of a microstrip patch antenna array operating at UHF frequency. This will further improved the antenna with very directive characteristics or very high gains to meet the demands for long distance communication. These design considerations such as slot can be considered in rectangular arrays by designers to improve a wide variety of structures to meet the often conflicting needs for different

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applications. And also changing of feed with recent techniques, consideration of optimizing modes can be introduced.

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