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A Review of Rectangular Shape Microstrip Patch Antenna for Wireless Communications

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ABSTRACT-

Microstrip patch antenna (MPA) is attracting considerable attention due to its small size and high performance. MPA is suitable for electronic gadgets and wireless communication devices under 4G and 5G communications. The purpose of this paper is to review microstrip antennas for various applications. The design of microstrip patch antennas is a new research area developed for use in 5th generation communications applications. An antenna is a collection of several devices linked together to act as an antenna for sending or receiving radio waves. Antennas can be of various shapes and sizes. Firstly, this paper gives a brief introduction about wireless technology and microstrip patch antenna, then a literature review is presented to understand the concept of microstrip patch antenna, which is compact in size and has multiband/wideband features. are, and are widely useful in wireless communications. The results of various investigations are discussed which are based on antenna performance factors such as return loss, bandwidth, gain, etc. For better understanding, these findings are depicted in tabular form and finally discussed in the conclusion of the review paper.

KEYWORDS - Microstrip antenna; Rectangular shape; DGS.

1. INTRODUCTION

The wireless industry is expanding every day. An important component of wireless communications is the antenna. The wireless and mobile technology used now is the fourth generation technology and very soon this technology will transform into 5G technology. MPA design is helpful for communication with electronic devices or any small device. MPA is compact, lightweight and profit-oriented. Recently, a large variety of antenna layouts and designs have emerged. Most satellite and radar communications occur in the high frequency bands between 18GHz and 100GHz. The physical antenna structure and traditional wireless communication optimization algorithms need to be improved because existing technology cannot support the requirements of 5G communication. Antennas are an essential component of the telecommunications industry. In more simple terms, it is a transducer that converts radio signals into electrical energy and electrical energy into radio signals. Wireless communication technology enables the transmission and reception of signals between people living in geographically inaccessible locations so that they can communicate with each other. Nowadays, a variety of applications use microstrip patch antenna (MPA), which is popular due to its small volume, low cost, and low profile.

The performance of a microstrip patch antenna can be improved by optimizing its design for many different factors. The use of printed antennas in wireless communications is possible at different frequencies of operation. Today we live in a fast-paced and constantly evolving world of wireless communications. Dual or multiband antennas have played an important role in the development and expansion of various wireless service application types. Within the scope of microstrip antennas, there has been a significant number of design and development activities focused on application specifications. Microstrip patch antennas and predictive antennas are both common types of antennas. Predictive antennas have better analysis and greater gain compared to microstrip patch antennas. To cater to all these wireless applications, we need an antenna that is very compact and very well organized.

Antennas play an important role in our daily life. This time period also saw the development of mobile and cellular technology as well as more convenient antenna technology. The future is bright for microstrip patch antennas because they are smaller and lighter and can operate at two or three frequencies. They can also support both circular and linear polarization. The fact that MPAs have all these features indicates that they are suitable for a wide variety of application systems. A ground plane is placed on one side of the dielectric substrate, and a radiation patch is placed on the opposite side. This is how it has been constructed. The radiating patch is located on one side of the substrate. The diagram labeled Figure 1 provides a summary of the MPA. The patch is usually made from a conductive material such as copper or gold, and can take any possible shape (for example square, rectangular, biconvex, circular, triangular, annular elliptical) as shown in Figure 2.

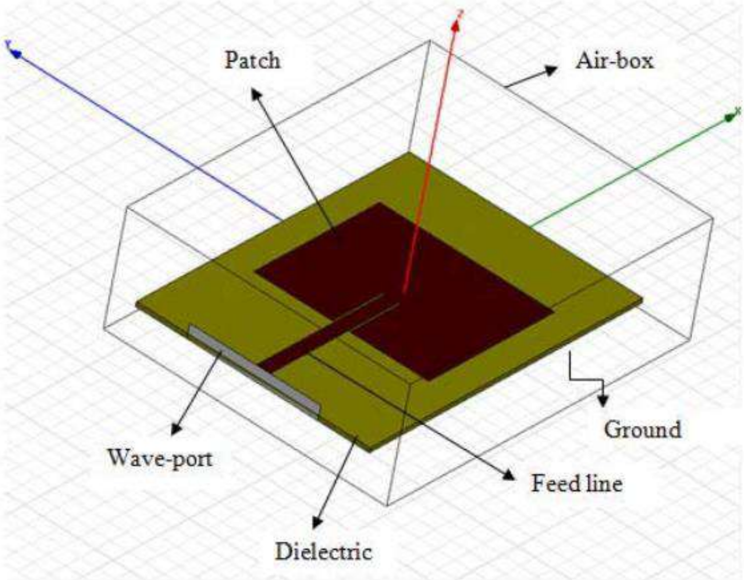

Figure 1. Microstrip patch antenna

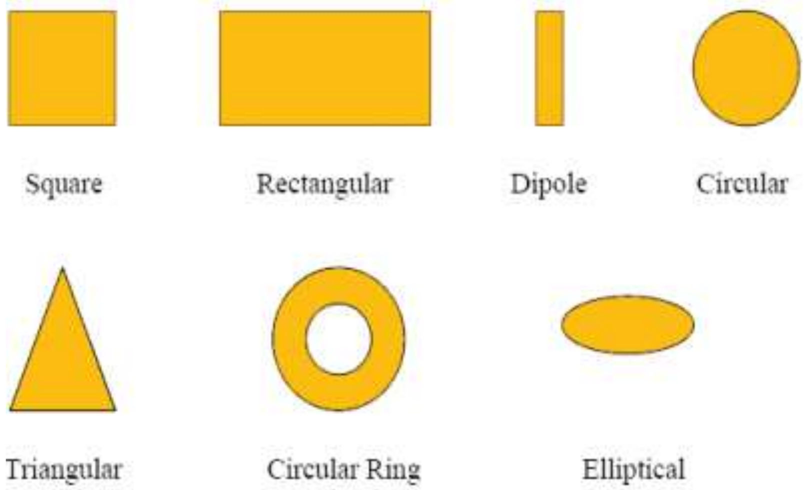

Figure 2. Microstrip antennas for different shapes

2. LITERATURE SURVEY

Innumerable micro-trip patch antenna designs have been proposed by various researchers. The main objective behind this literature survey is to summarize all the details related to designing the patch, improving various performance parameters of the antenna.

Mungur and Duraikannan [1] presented a design of a 28 GHz microstrip patch antenna used for various fifth generation applications. This antenna was originally designed to resonate at 27.91 GHz for the local multiport distributor band. The antenna configuration is presented. Microstrip inset line feeding was implemented on a rectangular patch antenna to operate it at 27.91 GHz. An 87.26 Ω quarter-wave transformer was connected between the proposed antenna and a 50 Ω microstrip line. This quarter wave transformer provides matching for a particular frequency, i.e. for which the transformer is quarter of the wavelength or it is inserted between the transmission line and the load to match the load impedance with the characteristic impedance.

Kumar and Chandramma [4] have proposed a new design of rectangular micro-strip antenna. The design starts with a conventional rectangular micro-strip antenna named CRMA. Two vertical and two horizontal slot loaded rectangular micro-strip antenna were then designed and named TVSTHSRMA. In this design two horizontal slots are placed along the width and two vertical slots are placed along the length of the ground plane. Also two horizontal slots have been removed from TVSTHSRMA and this antenna has been named two vertical slot loaded rectangular micro-strip antenna (TVSRMA). Inserting a slot increases the gain of the antenna and also reduces the patch size. The conventional antenna resonates for a single band of frequency. In the case of TVSTHSRMA, it resonates for five bands of frequencies. In the case of TVSRMA the antenna is resonant for seven bands.

TVSRMA's profit was higher than TVSTHSRMA. The change in frequency was achieved by varying the size of these slots. The effect of antenna resonant frequency and other performance parameters due to the metal strip in the patch was also presented in this paper. Some important points given by the author of this paper are that to improve the performance of micro-strip antenna, the antenna size is kept equal to λ/2 as it is responsible for efficient radiation in the antenna. If the antenna length is less than λ/2 then the radiation efficiency of the antenna will also reduce along with other antenna parameters.

Kothari and Sharma [10] designed a rectangular patch shape microstrip antenna to increase the bandwidth and frequency response by using the method of cutting U shaped slots from the patch. The advantages of using U slot are that it increases bandwidth and provides compact structure antenna.

Saini and Aggarwal [13] presented a study where antenna patches using a single H-shaped and two inverted E-shaped slots were discussed. Cutting these slots from the patch increases the band width of the antenna. The results of the proposed antenna were compared with the U slot patch antenna at 60 GHz and it was found that its return loss, bandwidth and antenna size are better than that of the U slot.

Verma et al. [19] designed a compact micro-strip antenna for fifth generation application using rectangular shape patches. The proposed antenna is good for electronic devices like mobiles due to its compact dimensions. It covers the frequency band range from 9.95 GHz to 10.35 GHz. Microstrip line is used for feeding. HFSS is used for antenna optimization. There is good agreement between the simulated and measured results of the proposed antenna.

Table 1: Comparison of Reported Microstrip Patch Antenna Studies

Ref.	Element Shape	Analyzed Parameter	Technique Used
Mungur and Duraikannan [1]	Rectangular	Gain=6.69dB BW=582MHz ReturnLoss=-12.59dB VSWR=1.77	Inset Feeding: Gain Increases
Kumar and Chandramma [4]	Rectangular	Gain=3.45 dB	Rectangular Slot on Ground Plane: Increase Gain, Multiband
Kothari and Sharma[10]	Rectangular	Gain = 4.06 dB ReturnLoss=-20dB VSWR=1.02	U Shape Slot: Increase Gain, Increase VSWR
Saini and Agarwal [13]	Rectangular	Gain=5.48dB ReturnLoss=-40.99dB BW=4028 MHz	E and H Shape Slot: Increase Gain, Increase BW
Vermaetal. [19]	Rectangular	Gain=2.31 dB Return Loss=-18.27dB BW=400 MHz	Rectangular Slot on Patch: Increase Gain

Various techniques are used in microstrip patch antenna to improve the performance, parameters were addressed in the above section. This section provides a distinction between various tests of antennas, taking into account various technical parameters such as BW, antenna gain and return loss. Comparison of investigations using different techniques shows that:

• Fractal geometry with rectangular slot technology will provide maximum profits.

• A maximum value of 4028 MHz band width and -40.99 dB return loss is achieved by using E and H shape slot insertion technology on the patch.

Rovin Tiwari was discussed that Microstrip patch antenna (MPA) is attracting a lot of attention due to its small size and high performance. The wireless industry is expanding every day. An important component of wireless communications is the antenna. The wireless and mobile technology used now is the fourth generation technology, and very soon, this technology will be transformed into 5G technology. The MPA design is helpful for communication with electronic devices or any small device.

MPA is compact, lightweight and profit-oriented. Recently, a large variety of antenna layouts and designs have emerged. MPA is suitable for electronic gadgets and wireless communication devices under 4G and 5G communications. This paper presents the design of 2X2 and 4X4 rectangular shape MPA array designed and fabricated for 5G wireless communication system. Four different frequencies, 4.1 GHz, 4.5 GHz and 5.5 GHz, are achieved with a maximum output of 7.69 dBi and a bandwidth of 829 MHz. This design is based on the state-of-the-art design of rectangular shaped patch antenna with partial ground.

Proposed work:

1. 4X4 rectangular shape MPA array designed and fabricated for a 5G wireless communication system. antenna array as 2X2 with a dimension of the single rectangular element is 6 mm X 10 mm. The partial ground dimension is the same as 25mm X 8 mm. The fed patch dimension is 6mm X 2mm.
2. The design is based on the cutting-edge design of a rectangular shape patch antenna with the partial ground.
3. To find the Return Loss, VSWR directivity and Gain of 4X4 rectangular shape MPA.

3. ADVANTAGES OF MICROSTRIP PATCH ANTENNA

1. Microstrip feeding lines are easy to fabricate, easy to match through internal position control, and easy to model. However, as substrate thickness increases, surface waves and spurious feed radiation increase, which limits the bandwidth of practical designs.

2. Microstrip antennas are relatively cheap to fabricate and design due to their simple 2D physical geometry. These are commonly used at UHF and higher frequencies because the antenna size is directly related to the wavelength at the resonance frequency.

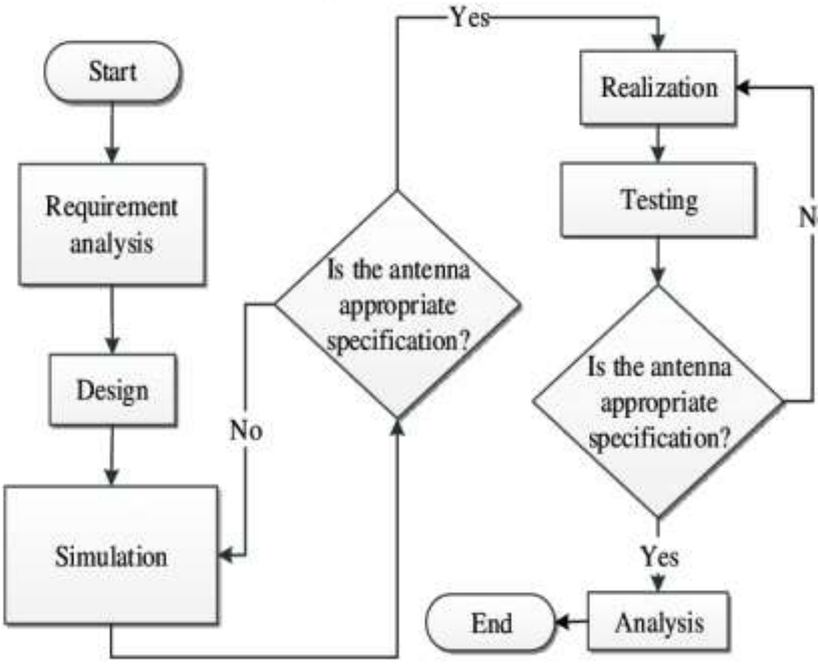

Figure 3. Flow chart of antenna development

4. METHODS OF ANALYSIS OF MICROSTRIP PATCH ANTENNA

The most common methods to analyze microstrip patch antennas are the transmission line model, the cavity model, and the full-wave model (mainly including the integral/transient method). The power line model is the simplest and provides good physical understanding but is less accurate. The cavitation model is very accurate and provides good physical understanding but is inherently complex. Full wave models are very accurate and flexible and can handle single elements, finite and infinite matrices, stacked elements, arbitrary shaped elements, and intersections.

There are several methods for analyzing microstrip antennas; The most common is a transmission line (where we assume that the patch is a transmission line or part of a transmission line). The second method is cavity placement (here we assume that the patch is a cavity filled with insulating material). The transmission line method is the easiest way to study a microstrip antenna. In this method, the transmission line model represents a microstrip patch antenna with two slots, separated by a low-impedance transmission line of length L. The results obtained are not the most accurate compared to other methods, but they are good enough.

4.1 FEED METHODS

There are mainly four basic methods for the feeding to these antennas

a) Probe Coupling Method

b) Microstrip Line Feeding Method

c) Aperture Coupled Microstrip Feed Method

d) Proximity Coupling Method

5. PARAMETERS

5.1 RADIATION PATTERN

The radiation pattern emanating from the antenna is an electromagnetic wave, and we are interested in calculating and measuring the power of this electromagnetic wave at a distant point. This far point is located somewhere in space where the wave is flat and normal to the direction of the antenna. Radiation patterns can be represented by Cartesian or polar coordinates. In this work we will discuss more antenna parameters regarding microstrip patch antenna such as radiation pattern, efficiency, quality factor, directivity, gain and more.

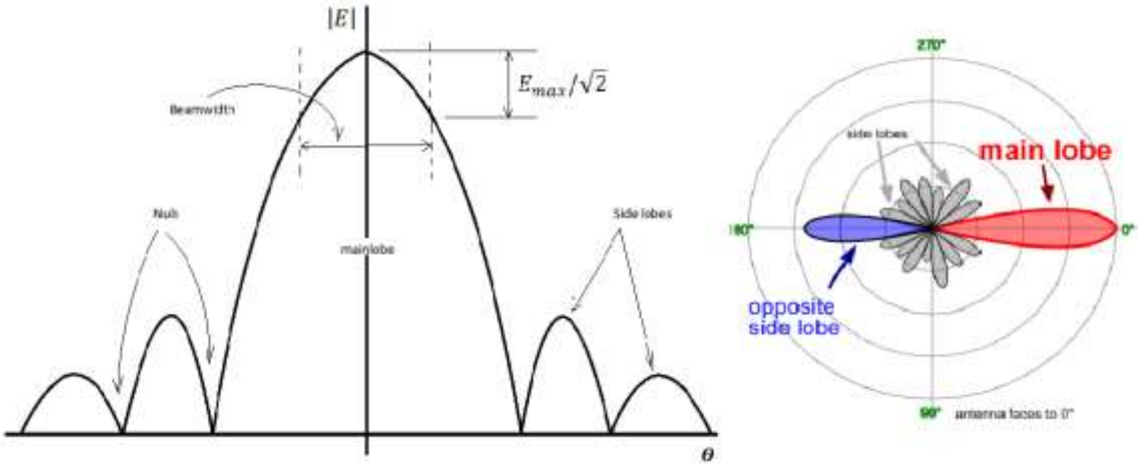

Figure 4. Radiation pattern; cartesian and polar diagram

5.2 DIRECTIONAL ANTENNAS

Talking about a dipole antenna means talking about omnidirectional antennas that radiate in all directions. Directional antennas are another category of antennas. The term directional antenna is used for antennas that transmit energy in a specific, focused direction. Directional antennas may be fixed to a specific location and directed toward the receiver (or transmitter), as in microwave communications, or may require features for rotation, as in radar. The ability of an antenna to concentrate more energy in one direction than in other directions is a measure of antenna quality and is often expressed in terms of gain, directivity, front-to-rear ratio, HPBW beam width at half power and many others.

5.3 EFFICIENCY AND QUALITY FACTOR

For a microstrip antenna, efficiency can be defined by dividing the power radiated from the microstrip element by the power received by the element input. Factors that affect the efficiency of an antenna and make it high or low are dielectric loss, conductor loss, reflected power (voltage standing wave ratio VSWR), cross-polarization loss, and dissipation at any load on the element.

5.4 POLARIZATIONS

Polarization can be classified into linear, circular and elliptical. In linear polarization, the antenna radiates power in only one plane, in the propagation plane, and when the electric field is perpendicular to the Earth's surface, the antenna is linearly polarized perpendicular to and when the electric field is parallel to the Earth's surface, then the antenna is horizontally linearly polarized. A circularly polarized antenna radiates power in all planes in the direction of propagation (vertically, horizontally and in between). The propagation plane rotates in a circle resulting in one complete cycle within the period of one wave. Return loss is an important parameter when testing an antenna. It is all about impedance matching and maximum power transfer principle. It is also a measure of the antenna's efficiency in delivering power from the source to the antenna.

6. CONCLUSIONS

This survey analyzes and discusses various designs of microstrip patch antennas as well as the applications of these antennas in contemporary technology. A detailed overview of the research work being done to improve the performance parameters of microstrip antennas was presented in a comprehensive literature review. It is concluded that by using techniques like fractal geometry and insertion of slots the desired values of various performance parameters like bandwidth, gain and return loss can be achieved. Some suggestions for future improvement are given such as to get better results, improvements in the geometry of the fractal structure can be further explored. Various techniques, such as using parasitic patch and reflective layer, replacing the conventional substrate with air substrate, etc., can have a great advantage in achieving the performance parameters of the microstrip antenna.

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