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A Review Paper on Circularly Polarized Microstrip Patch Antenna

Akshay Goyal, Aastha Gupta, Lavi Agarwal

***Abstract*— In this paper description of microstrip patch antenna is presented, along with the use of circular polarization and cavity to improve basic antenna characteristics. To achieve polarization matching between transmitting and receiving antenna use of circularly polarized antenna is an effective solution. Use of cavity in this antenna helps in suppressing surface waves and increases bandwidth of the antenna.**

***Index Terms*— Axial Ratio, Cavity, Circular Polarization, Microstrip Patch Antenna.**

I. Introduction

Due to the limitations of wired communication that are- the receiver and transmitter are fixed at a particular location and the use of wires increases the systems complexity and make the system bulky, the need was felt for the wireless communication. Wireless communication can be achieved easily with the help of antenna.

With the increasing use wireless applications it is required to have low cost, light weight and miniature antennas so that it can be easily fabricated on a small chip. For the same the best suited antenna is cavity backed circularly polarized microstrip patch antennas (CPMSAs). In such type of antennas it is not required to consider the device orientation. These antennas are more suitable for wireless communications such as GSM, WLAN, RFID and biomedical sensing applications.

The most commonly used polarization technique in today's communication is circular polarization (CP) as it is not concerned with the orientation of the transmitting and receiving antennas.

In microstrip patch antenna (MSA), CP can be produced by using dual feed or by using single feed by making some modifications in the patch (such as making some perturbations, making slots and slits or by truncating corners).

To further enhance the frequency bandwidth of the patch antenna we can use a metallic resonator (known as cavity) behind the patch which increases the thickness of the substrate but helps in suppressing the surface waves and back lobes.

Akshay Goyal, Electronics and Communication Engineering, Moradabad Institute of Technology, Moradabad, India.
Aastha Gupta, Electronics and Communication Engineering, Moradabad Institute of Technology, Moradabad, India,
Lavi Agarwal, Assistant Professor in Electronics And Communication Engineering, Moradabad Institute Of Technology, Moradabad, India,

II. MSA

MSAs are the low cost, light weight, conformal antennas which can be integrated with feed networks and active devices.

It was first proposed by sir Deschamp in 1953 but the practical antenna was given by sir Munson and Howell in 1970s.

The basic structure of MSA consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side of the substrate.

A microstrip patch antenna is shown in fig.1. Patch is generally made up of conducting material like copper or gold and it can be of any possible shape. The patch and the feed lines are photo etched on the substrate.

As this antenna is etched on the substrate so it can take any desired shape. Rectangular shaped patch is the simplest patch shape to be etched and analyzed.

The radiation pattern of an antenna depends on its dimensions. It also depends on the effective permittivity of the substrate which is dependent on the width and height of the patch as given in equation (1).

$$\epsilon_e = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + \frac{10h}{W}\right]^{-1/2} \quad (1)$$

An antenna is characterized on the basis of its gain, input impedance and bandwidth (BW). So now we are going to discuss the effect of physical dimensions on these parameters for a rectangular microstrip patch antenna (RMSA).

A. Effect of Width

Effect of increasing width of the patch on characteristics of antenna is:

- The resonance frequency decreases due to the increase in effective length and effective permittivity.
- The input impedance decreases.
- BW of the antenna increases.
- By increasing the width, aperture area of the antenna increases, which results in the increased directivity, efficiency and gain of the antenna.

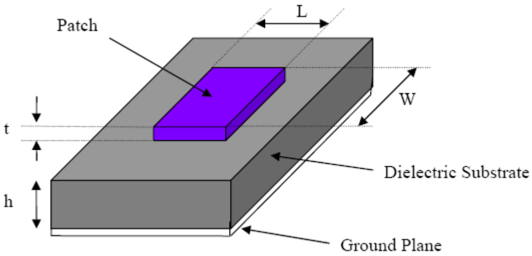

Fig. 1 Microstrip Patch Antenna

B. Effect Of Height

Effect of increasing height of the patch on characteristics of antenna is:

- Resonance frequency decreases with the increase in the height.
- The BW of the antenna increases.
- If we use coaxial feeding in this arrangement an inductive shift will occur in the input impedance as the length of the probe changes.
- Directivity of the antenna increases.

C. Effect Of Relative Permittivity (ϵr)

When the relative permittivity is increased, bandwidth and resonance frequency of the RMSA increases.

III. FEEDING TECHNIQUES

A MSA can be feeded directly or indirectly. For direct feeding there are two methods- coaxial feeding and microstrip feeding.

For indirect feeding also there are two methods- proximity feeding and aperture coupling method. Various feeding techniques are shown in Fig.2.

Feeding technique are the important designing parameters- as coaxial feeding can be connected anywhere in the patch and it provides a matched input impedance which depends upon the dimensions of coaxial feed but there is a certain limitation in this feeding technique that it makes structure asymmetrical and if the substrate is thick inductive impedance will change.

Another direct feeding technique is microstrip feed, in this feeding lines are etched on the substrate and due to the same reason structure symmetry is not distorted but it has a limitation that the size of the feed line is comparable to patch which results in increased cross polar levels.

Another feeding technique is indirect feeding- Proximity feeding is one example of this, proximity feed reduces the cross polar levels and the bandwidth of the antenna is also increased but it have alignment problem and the thickness of the antenna also increases.

Another method for indirect feed is aperture coupling, it reduces cross polar levels, bandwidth is increased and has no alignment problem.

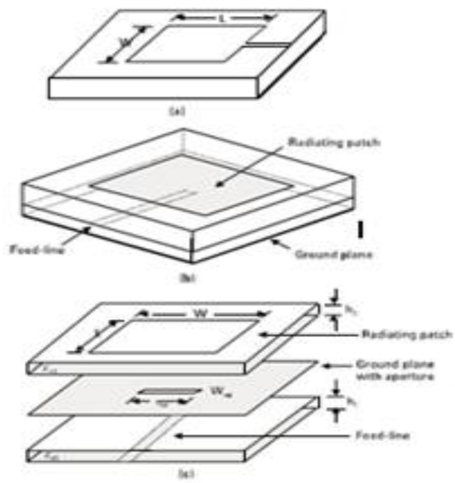

Fig.2 Rectangular MSA Fed by (a) Microstrip Feed (b) Electromagnetic Coupling (c) Aperture Coupling

IV. POLARIZATION

Polarization is that property of electromagnetic wave describing the time-varying direction and relative magnitude of the electric field vector as observed along the direction of propagation.

Transmitting and receiving antennas should be similarly polarized otherwise there will be more losses.

On the basis of axial ratio polarization is of three types- linear polarization, circular polarization and elliptical polarization.

Transmitting and the receiving should be similarly polarized otherwise there will be more losses. If we use linear polarization then the alignment of transmitting and receiving antenna should be proper. This limitation of alignment can be removed by using circular polarization.

A. Circular Polarization

Circulation polarization (CP) can be achieved by making axial ratio equal to one.

Circular polarization is of two types- Right Hand CP (RHCP) and Left Hand CP (LHCP).

When a circularly polarized wave strikes with a metallic object, its sense of polarization changes, as a result of which the receiving antenna can differentiate between the waves coming from direct path and indirect path. CP also helps in increasing the bandwidth of MSA.

CP can be achieved by dual feeded MSA (that can be achieved by exciting two orthogonal modes with equal amplitude, which are in phase quadrature) and by using single feeding technique (it can be achieved by modifying the shape of the MSA). In fig. 3 various modified square MSAs are shown for achieving circular polarization using single feed technique.

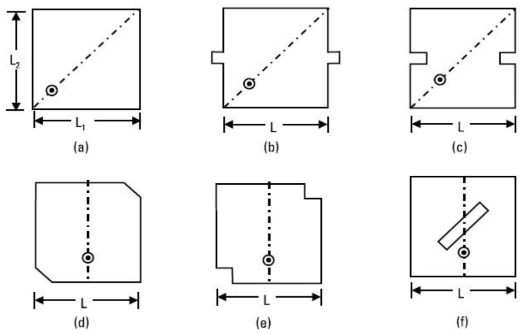

Fig.3 Various Single Feed Modified Square MSA Configuration (a) Diagonally Fed Nearly Square and Square With (b) Two Stubs (c) Two Notches (d) Two Corner Chopped (e) Square Notches at Two Corners and (f) Diagonal Slot

V. CAVITY BACKED PATCH ANTENNA

Any hollow metallic space can be considered as cavity. In MSA cavity can be a partly open metallic resonator placed behind the patch. A cavity backed antenna is shown in fig. 4.

In MSA the major limitation is of limited bandwidth, which can be removed by increasing the thickness of the substrate but thick substrates increases the surface waves which in turn reduces the gain, limits the bandwidth increase cross polarization and due to the increased thickness back lobes also increases. To avoid these effects a metallic cavity is used behind the patch.

Characteristics of a cavity are-

- It suppresses back lobes.
- It suppresses surface waves
- It acts as a heat sink for the antenna.
- Gain of the antenna can be improved by inclusion of high permittivity substrates on the cavity backed patch antenna.
- A rectangular cavity can suppress noise.

VI. SLOTS IN CPMSA

Various shaped slots can be made in a MSA such as circular, rectangular, disk, annular ring, cross shaped etc.

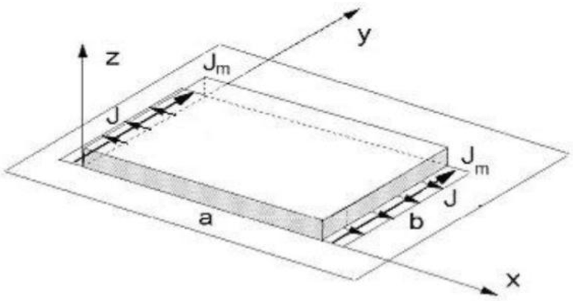

Fig. 4 Cavity Backed Patch Antenna

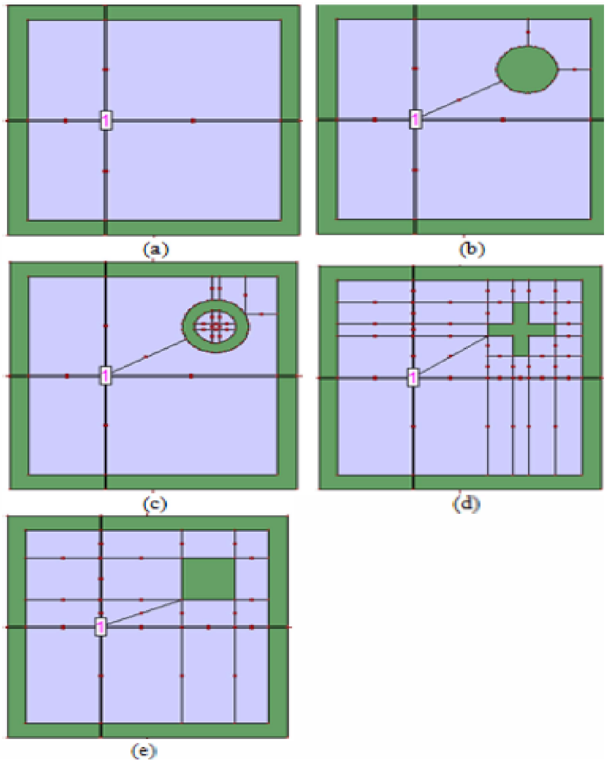

Fig.5 (a) Probe Feed MSA (b) Circular Shaped Slotted MSA (c) Circular Ring Shaped Slotted MSA (d) Cross Shaped Slotted MSA (e) Square Shaped Slotted MSA

In fig. 5 we have shown slots of various shapes of slot in MSA [9].

Following observations are recorded-

- To obtain CP axial ratio should be equal to 1(ideal case). Axial ratio of circular slot is most nearest to 1 in comparison to other slots as shown in the graph of fig. 6 [9].
- Antenna performance can be characterized by gain. Gain of circular slotted MSA is maximum of all the slots shown in the graph in fig. 7 [9].

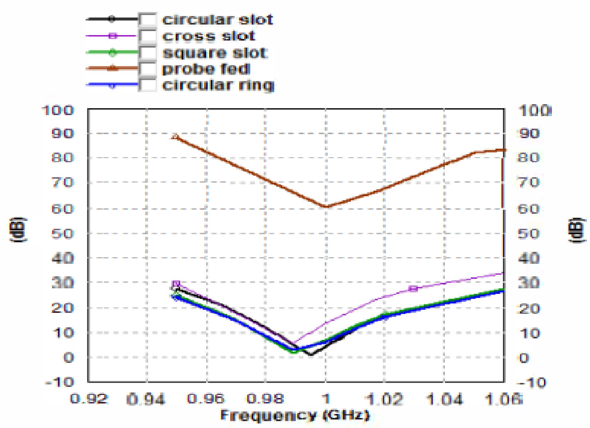

Fig. 6 Axial ratio vs. Frequency Graph for Different Slots

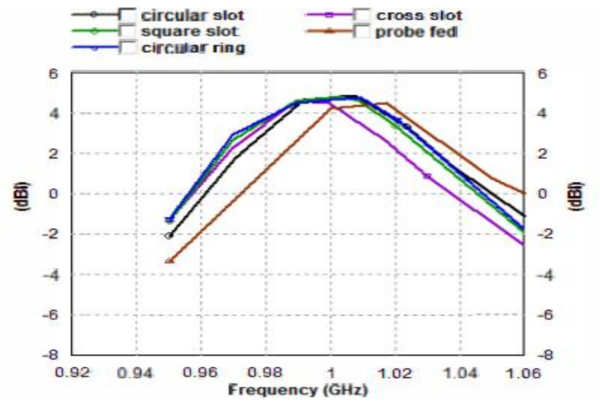

Fig.7 Gain vs. Frequency Graph for Different Slots

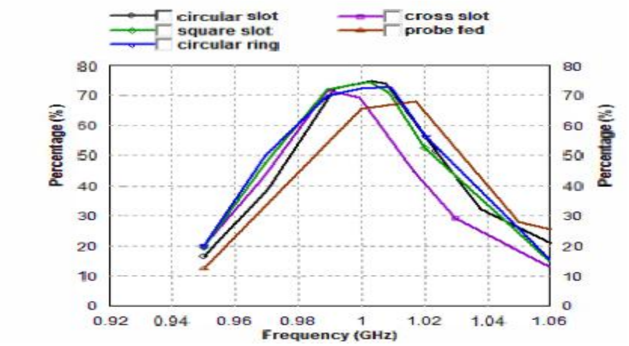

Fig. 8 Antenna Efficiency vs. Frequency Graph For Different Slots

- Efficiency of MSA without slot is less than the slotted MSA. Antenna efficiency is maximum for circular slots as compared to other slots as shown in the graph in fig. 8 [9].

VII. TEXTILE ANTENNA

In textile antenna radiating patch and ground plane are made up of conductive textile material and the substrate is also made up of textile material with specific dielectric constant. Fig. 9 shows geometry of rectangular patch antenna for textile antenna [2].

Textile antenna can be used to monitor biometric data of the human body, as for this purpose antenna should be very close to the human body and as this antenna is made up of textile it will not harm human body and can be integrated in everyday clothing. They continuously monitor the human body and send the information to the outside world. It can also be used for tracking and navigation, mobile computing and public safety [9]. This antenna is tested at 2.45 GHz ISM unlicensed frequency [2].

In fig. 10 a fabricated textile antenna is shown [2].

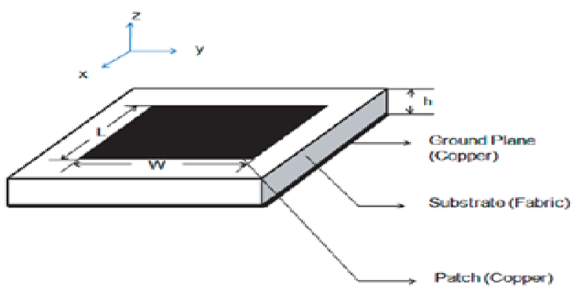

Fig.9 Geometry of Rectangular Patch Antenna.

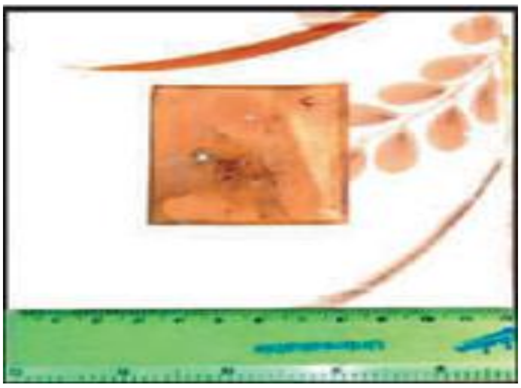

Fig.10 Photograph of Fabricated Textile Antenna

VIII. CONCLUSION

The goal of this review paper is to describe the simple microstrip patch antenna and ways to improve its performance to enhance its applicability. Basically bandwidth of the microstrip antenna is its main limitation. Through this review paper we presented that by modifying the shape of the patch antenna or by using different feeding techniques circular polarization can be achieved which helps in increasing the bandwidth of the MSA. We also presented differently slotted MSA and it is clearly shown that shape and size of slot also helps in achieving increased bandwidth, improved efficiency and gain. Use of cavity reduces the surface waves which enhances antenna efficiency. So by using cavity backed circularly polarized microstrip patch antenna we can achieve an antenna with a better performance.

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My name is Akshay Goyal, I am from Bijnor, I have done my schooling from Modern Era Public School, Bijnor, Uttar Pradesh, India. Presently I am pursuing B.Tech from Moradabad Institute of Technology, Moradabad, India and my branch is Electronics and Communication Engineering .

My name is Aastha Gupta, I am from Moradabad, I have done my schooling from K.C.M Senior Secondary school, Moradabad, Uttar Pradesh, India. Presently I am pursuing B.Tech from Moradabad Institute of Technology, Moradabad, India and my branch is Electronics and Communication Engineering.

My name is Lavi Agarwal. I am from Moradabad, I have completed my B.tech (E.C.) from Bhagwant Institute of Technology in June 2011 and M.tech (E.C.) from IIMT engineering technology in November 2015. At present I m working as a assistant professor in E.C. department, Moradabad Institute of Technonoly, Moradabad.