RELATED REVIEW ON MICROSTRIP PATCH ANTENNAS

[1]WAHEED MOHMMED KHAN, [2]SANJAY M.GULHANE

[1,2]Department of Electronics and Telecommunication, J.D.I.E.T, Yavatmal, Maharashtra, India.
E-mail: wahid.khan74@gmail.com, smgulhane67@rediffmail.com

Abstract- Microstrip patch antenna is very demanded and important discussion thread in the theory of antennas because of its several advantages over conventional antennas like low cost, light weight, easy to feed and their attractive radiation characteristics. It has been a topic of interest for the researchers where must the research is concerned around minimization of antenna size while achieving high gain and bandwidth. This paper presents the overview study of microstrip patch antenna in past few decades, Arrangement of arrays in antenna by various topologies, composite antenna, highly integration of antenna/array and feeding network, operating at relatively high frequencies, used of advanced machining techniques, has been the various techniques proposed for achieving improved performance of microstrip patch antennas.

Keywords- Microstrip Patch Antenna, Design parameter, Feeding technique, Bandwidth and Gain Enhancement, Miniaturization of Antenna.

I. INTRODUCTION

Wireless communication having huge demand of antennas system and their miniaturization, antenna design becomes more and more challenging and required. Recently microstrip patch antennas have been extensively used in satellite communications, military, aerospace communication, radars, biomedical and for mobile communication because of its inherent characteristics. The concept of microstrip antenna was first introduced in the 1950s.

However, this idea had to wait nearly 20 years to be realized after the development of the printed circuit board (PCB) technology in the 1970s. Since then, microstrip antennas are considered as the most common types of antennas due to their obvious advantages of light weight, low cost, low profile, planar configuration, easy of conformal, superior portability, suitable for arrays, easy for fabrication, and easy integration with external circuitry like microwave monolithic integrate circuits (MMICs) and probably all integrated circuit. That's why it has the wide arera of application for the civilian and military applications such as television, broadcast radio, mobile systems, radio-frequency identification (RFID), Wi-Fi, Wi-Max, multiple-input multiple-output (MIMO) systems, global positioning system (GPS), satellite communications, surveillance systems, vehicle collision avoidance system, direction founding, radar systems, remote sensing, biological application like biological imaging, missile guidance, and so on and still the work is carry on the microstrip antennas for finding new applications of it by having more integration.

A) Microstrip patch Antenna:

Antennas are based on transmission or reception of electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and therefore are used in a variety of practical applications. Microstrip antenna in its simplest design is shown in Figure 1. It consists of a radiating patch on one side of dielectric substrate ($\epsilon r \leq 10$), with a ground plane on other side.

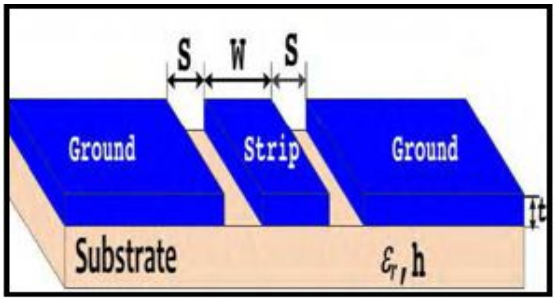


Figure 1: Microstrip antenna with substrate and ground

A microstrip patch antenna (MPA) consists of a conducting (metallic patch on a thin, grounded dielectric substrate) patch of any non-planar or planar geometry on one side of a dielectric substrate and a ground plane on other side. It is a printed resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been widely utilized. The rectangular and circular patches are the basic and most commonly used microstrip antennas. The characteristic impedance of the microstrip line is determined by the substrate thickness, strip, width and dielectric constant.

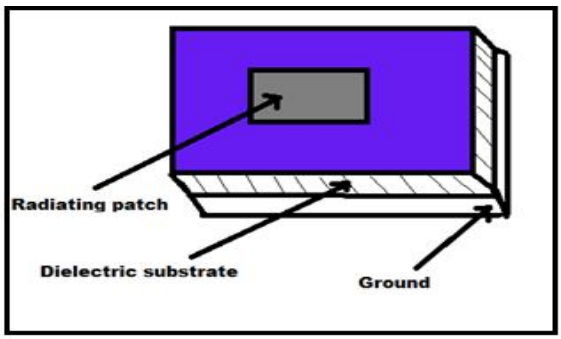


Figure 2: Microstrip antenna showing the radiating patch

B)Microstrip Patch Antenna Design:

Microstrip patch antenna consists of very thin metallic strip placed on ground plane where the thickness of metallic strip is restricted by $t << \lambda_0$ and the height is restricted by $0.0003\lambda_0 \leq .05\lambda_0$ (where λ_0 is wavelength) microstrip patch is designed so that its radiation pattern is maximum normal direction to the patch. For example rectangular patch having the length of the element is usually $\lambda 0/3 < L < \lambda 0/2$. There are numerous substrates that can be used for the design of microstrip patch antennas depending upon different properties like temperature range, conductivity, dimensional stability and their dielectric constants (ε_r). Dielectric constants are usually in the range of $2.2 \leq \varepsilon_r \leq 12$. The substrate is can be consider Fr-4 lossy (ε_r =4.33) is subjected to implement the rectangular microstrip patch antenna. The performance of microstrip antenna depends on its dimension, operating frequency, radiation efficiency, directivity, return loss etc.

Designing Parameters of MSPA:

The microsrtip patch antenna Designing Parameters are usually done by pre-calculations of width, Effective Dielectric Constant, the Actual Length of the Patch, Calculation Of Length Extension, Return Loss Curve, Gain, Directivity, Voltage Standing Wave Ratio and Bandwidth etc. for well known performance of antenna.

1) Width :

The width can be formulated as:

$$W = \frac{C}{2fr\sqrt{(\varepsilon r + 1)/2}}$$

Where, c = free space velocity of light

ε_r = Dielectric constant of substrate

2) Effective Dielectric Constant Calculation:

The effective dielectric constant (ε_{reff}) is less than (ε_r) because the fringing field around the periphery of the patch is not confined to the dielectric speared in the air also.

$$\varepsilon_{eff} = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}[1 + 12\frac{h}{w}]^{-1/2}$$

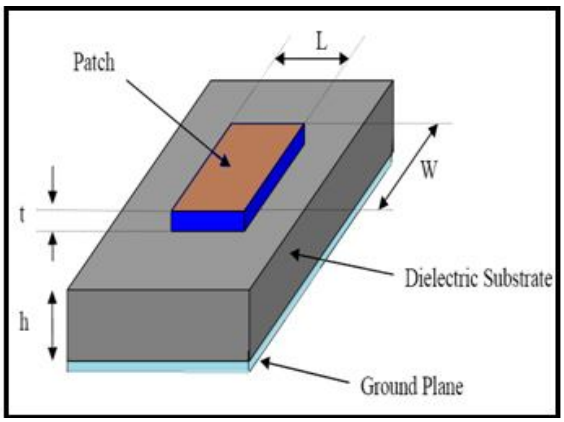


Figure 3: Structure of a Microstrip Patch Antenna

3) The Actual Length Of The Patch (L):

The difference in the length (ΔL) which is given by:

$$L_{eff} = \frac{C}{2fr\sqrt{\varepsilon_{ref}}}$$

$\Delta L = 0.86mm$ $\quad L = L_{eff} - 2\Delta L$

4) Calculation Of Length Extension:

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon\, eff + 0.33)(\frac{\omega}{h} + 0.264)}{(\varepsilon\, eff - 0{,}258)(\frac{\omega}{h} + 0.8)}$$

5) Return Loss Curve :

This Return Loss is determined in dB given as follows:

$RL = -20\log|\Gamma|$ (dB)

Where $|\Gamma|$ is $= \frac{V0^-}{VO^+} = \frac{Z_L - Z0}{ZL + Z0}$

$|\Gamma|$ is the reflection coefficient

vo+ the incident voltage

v0- the reflection voltage

ZL and Z0 are characteristics impedances

6) Gain And Directivity:

The expression for the maximum gain of an antenna is as follows:

$$G = \eta \times D$$

η – The efficiency of the antenna D – Directivity

7) Voltage Standing Wave Ratio:

VSR is given as

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \frac{1 + S_{11}}{1 - S_{11}}$$

As the reflection coefficient ranges from 0 to 1, the VSWR ranges from 1 to ∞.

8) Bandwidth :

The bandwidth is the ratio of the upper and lower frequencies of an operation. According to the bandwidth can be obtained as:

$$BW_{BROAD\ BAND} = \frac{fH}{fL}$$

$$W_{narrow\ band(\%)} = \left[\frac{fH - fL}{fC}\right]100$$

When the ratio $f_L / f_H = 2$ the antenna is said to be broadband. We can judge the antenna's performance by operating the antenna at a high frequency by observing VSWR, when VSWR ≤ 2 ($R_L \geq$-9.5dB) the antenna is said to have performed well.

II. LITERATURE SURVEY:

In this section, the literature survey of microstrip patch antennas is discussed based on the previous work on microstrip antennas. The study shows that the microstrip patch antenna exhibits many noticeable advantages like light weight, low cost, low profile, planar configuration, easy of conformal, superior portability, suitable for arrays, easy for fabrication, and easy integration with external circuitries etc.

which make it as obvious choice. Though the typical microstrip antennas have many advantages but it also suffers from three basic disadvantages: narrow bandwidth, low gain, and relatively large size and many times these factors create an adverse impact in the antennas efficiencies.

The narrow bandwidth is one of the main drawbacks of these types of antennas. The direct method to improve the bandwidth can be done by increasing substrate thickness, but the major disadvantage of increasing thickness is the reduced efficiency since the large portion of the input power is dissipated in the resistor which takes away the available Power that can be radiated by antenna. Furthermore, reducing the height of the structure may appear to be a suitable solution, but it may lead to a reduced impedance bandwidth and lower radiation efficiency. This is often a tradeoff in realizing compact antennas while maintaining performance characteristics. Thus, different other improved techniques are adapted to provide wide-impedance bandwidths of microstrip antennas, including using high permittivity dielectric resonators for microstrip patch antenna but high permittivity substrate has a poor choice for antenna bandwidth, since the bandwidth of a microstrip antenna is best For low dielectric constant substrates as a portion of the total available power for direct radiation becomes trapped along the surface of the substrate. Compared to this single-pin-shorted three-dielectric layer substrate is used to improve the radiation efficiency and bandwidth without sacrificing, the cost and operational advantages. Another use of electromagnetic band gap (EBG) structures have attracted much attention in the recent years in the microwave community for its unique properties. These structures are periodic in nature that forbids the propagation of all electromagnetic surface waves within a particular frequency band – called the band gap – thus permitting additional control of the behavior of electromagnetic waves other than conventional guiding and/or filtering structures .Dummy EBG patterns that are etched effectively on the feed line connecting the two patches of a dual array patch antenna. These dummy EBG patterns are compact and small in size a good improvement in bandwidth (48.8% increase with a bandwidth). In Impedance matching the radiating patch needs not to be altered by using an Impedance matching circuit; so the radiation properties could be retained. In addition, the use of IM technique is independent of the choice of the patch substrate. Similarly by creating slot in microstrip antennas using the L, U, T, and inverted T slots in the ground plane for achieving Ultra WideBand (UWB).Slot antennas are popular omnidirectional microwave antennas.

Adding negative capacitor/inductor high gain can be achieved using a single almost rectangular microstrip radiator reactively loaded with active negative capacitor, and composite-resonator microstrip antennas using metamaterial resonators which provide wide bandwidth and high gain.

Similarly another problem to be solved is the low gain for conventional microstrip antenna element. Array topologies like dual patch antenna arrays, basically the term topology optimization is often used to label the most general type of design optimization methods, in which the shapes as well as the connectivity of individual parts of the device are subject to design. The most common way of carrying out topology optimization is through the material distribution approach, in which the design domain is divided into small elements, which together represent an image of the device, Cavity backing technique has been used to eliminate the bidirectional radiation pattern, which is used to provide higher gain compared with conventional microstrip antenna. Lens covering is an alternative way to achieve gain enhancement. The lenses with canonical profile, like hemi elliptical, elliptical, hyper-hemispherical, and extended hemispherical provide to focus the radiation beam from the radiator elements. The integrated microstrip lens antenna can be treated as composite antenna by combining microstrip radiator elements and dielectric lens together, which is very useful for high frequencies (mm, sub-mm, terahertz (THz), and optical waves) applications. Partial Substrate Removal in Multiple-layer Dielectric Substrate, It is also well known that antenna array is an effective means for improving the gain.

Similarly the last limitation of conventional microstrip antennas is minimization of the relatively large size, particularly at lower microwave frequencies, since the operational frequencies are related to the electrical size of antenna. In general, the size of the rectangular microstrip antenna (RMSPA) should be of order of a half-guided wavelength. This limitation was mathematically studied by Wheeler and Chu. There have been numerous efforts are made to minimize the antenna size and obtain the electrically small microstrip antenna with the raised demand towards smaller and smaller wireless communication devices. Inductive or capacitive loading is one of the effective ways to reduce the size of microstrip antennas. The size of microstrip antenna can be miniaturized using composite metamaterial resonators.

Magneto-dielectric substrates have been widely utilized to miniaturize microstrip antennas due to magnetic substrates can provide wider bandwidths than dielectric substrates. Fractal geometries (topologies), which are composed by self-similar structures, have opened an alternate way for antenna miniaturization.

From the above discussions, specified that many methods and materials are used to improve the

properties of microstrip antennas. However, there should be a certain relationship among bandwidth, gain, and size of the microstrip antennas.

The previous study has recognized that if there improvement in one antenna property is frequently accompanied by decline in its other property performances.

For example, if the size of an antenna is reduced then it is usually at the expense of its bandwidth and gain.

Therefore, a more comprehensive and compatible consideration must be given on further developments of microstrip antennas.

III. FEEDING TECHNIQUES

Different methods are available for feeding microstrip patch antennas. These methods can be contacting and non-contacting methods depends on the method. In the contacting method, the RF power is fed direct feed to the radiating patch using a connecting element such as a microstrip line. In the non-contacting method, power is transferred between the microstrip line and the radiating patch through electromagnetic coupling. There are many feed techniques but the four most popular feeding techniques used are microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

Table1: Demonstrating the feeding method

Feed Type	Connection	Advantages	Disadvantages
1. Line feed	The feed line is directly to the edge of MSPA	Simple Easy to use with Array	Thicker substrate reduced radiation Deep notches current and radiation pattern show distortion
2.Coaxial Feed	Inner –MSPA patch Outer–grounded substrate	Simpler Compatible with coaxial cable	Not easily compatible with array
3.Proximity-coupled Feed (EM couple feed)	Two dielectric substrate used and feed line is between the two substrate	Allows for planar feeding Less line radiation compared to microstrip feed	Requires multilayer fabrication Alignment is important for input match
4.Aperture-coupled Patch (ACP)	Radiation patch and microstip line are sep. by gnd. And patch & feed line is couple through a slot in gnd. plane	Allows for planar feeding Higher bandwidth	Requires multilayer fabrication Alignment is important for input match

IV. ANALYSIS FOR RECENT DEVELOPMENTS

In this paper, the analysis on previous works of microstrip antennas and few techniques are concentrated to minimize the drawbacks of MSPA. So that great success in concern to the wireless communication can be achieved.

The microstrip antenna can be design with different topologies to meet the desired requirement of variety of wireless application, such as high gain, ultra wide band (UWB), miniaturization, rectangular, circular polarization, multipolarization, feeding techniques, etc. The utilization using different dielectric materials ,composite materials to make composite antenna based on composing technique which having more capacity of transmission, less return loss more directivity etc.. Then finally with certain matching technique like full impedance matching, micro-/nano-machining techniques, and use of antennas/arrays with highly integration and with highly operating frequencies.

A). Variety Of Microstrip Antenna Topologies:
Microstrip antennas have widely used in commercial as well as military applications due to their attractive advantages. However, The conventional microstrip antennas have the impedance bandwidth of only a few percent, radiation pattern scattered means radiation pattern with omnidirection, which obviously does not satisfy the requirements of various wireless applications. To meet the desired requirement a wide variety of microstrip antenna topologies are adapted, including different microstrip antenna array element structures and different microstrip array arrangements, have been studied to meet the desired requirement such as ultra wide band (UWB), miniaturization, circular polarization, high gain, multipolarized, and so on. As, the microstrip antennas inherently have lesser bandwidth and lower gain compared to conventional bulky antennas. Some microstrip antennas with

special topologies, like material distribution topology optimization, UWB microstrip antenna based on the circular topology with stepped block, quasi-Yagi, planar reflector antenna, are used to replace the conventional bulky antennas.

B). Microstrip-Antenna With Composite Formation:
As many antenna designers are concern how to improve the antenna parameters like gain and bandwidth because it's come on the issue when more accurate and precise antenna design are required ,and it is not an easy task to meet the user-defined stringent performance requirements demanded by special wireless applications like missile guidance, satellite transmission, military radars, surveillances etc. . This difficulty may require the use of two more separate types or structures of antenna elements with different characteristics. Composite antenna formed by two more types or structures of antennas is particularly suitable for these concern applications due to more advantages offered by different types or structures of antennas. For example, it is a challenging task to use single type of antenna to design a dual-band dual-polarization antenna for satellite digital multimedia broadcast (S-DMB) application. A dual band circularly polarized ring antenna based on composite right and left handed metamaterials, Quad frequency linearly polarized and dual frequency polarized microstrip antennas with CRLH (Composite Right/Left-Handed). A composite antenna composed with a left-handed circularly polarized (LHCP) microstrip antenna and a linear polarized omnidirectional biconical antenna is proposed to meet this requirement, Composite antenna is comprised of a dielectric lens and microstrip log-period antenna, which has been widely applied to THz systems.

C). Advanced Machining Techniques :
The design of microstrip antennas is closely related with the machining techniques to have minimum return losses, proper transmission of data etc. Recently, various machining techniques, including complementary metal oxide semiconductor (CMOS), multilayer printed circuit board (MPCB), low-temperature cofired ceramics (LTCC), and micro-electromechanical systems (MEMS), are highly developed, opening opportunities for innovative antennas, such as active antennas, reconfigurable antennas, metamaterial-based antennas, THz antennas, and so forth.

With the availability of high-precision and high-speed advanced machining techniques, microstrip antennas are growing towards highly integration of antenna/array and feed network and operating at relatively high frequencies. Since they are all based on the advanced machining techniques, the highly integrate broad-band microstrip antenna array fabricated using MPCB technology. Another is THz wave planar integrated active microstrip antenna using MEMS technology.

V. SIMULATION RESULTS FOR RECTANGULAR MICROSTRIP PATCH ANTENNA(RMPA)

- Return loss curve for RMPA:

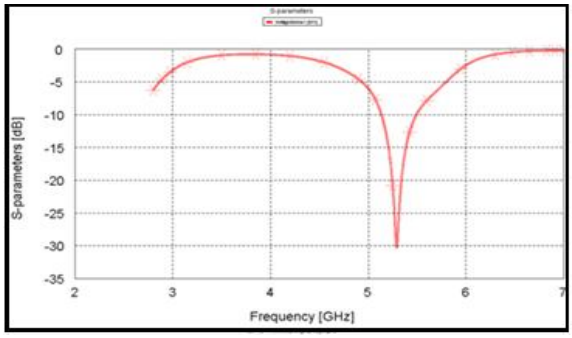


Figure 4: Return loss of Rectangular Microstrip patch antenna with Metamaterial structure.

- Current distribution:

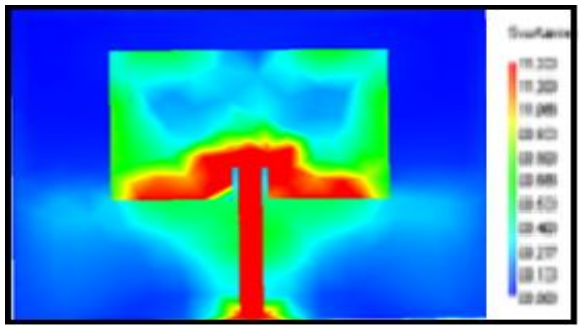


Figure 5: Current Distribution of Rectangular Microstrip patch antenna.

- Directivity for RMPA:

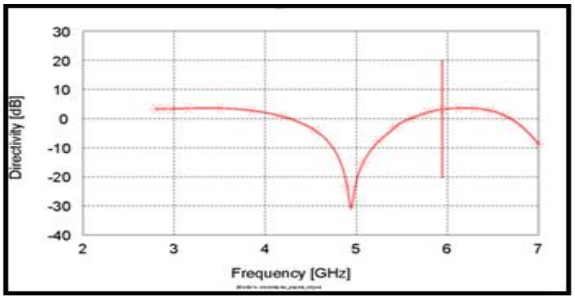


Figure 6:directivity for RMP antenna.

- GAIN FOR RMPA :

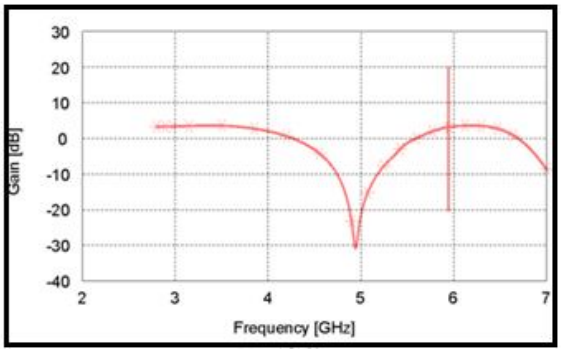


Figure 7: Gain designed forRMPA antenna

RADIATION PATTERN:

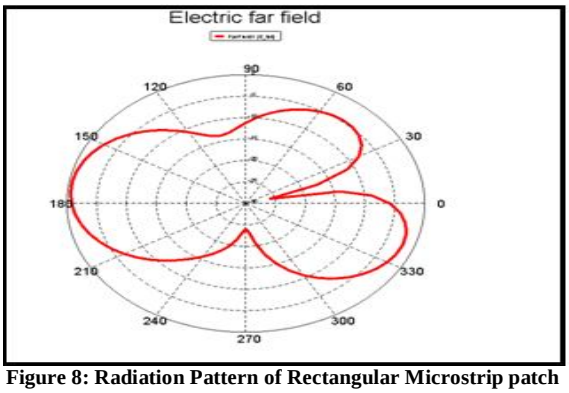


Figure 8: Radiation Pattern of Rectangular Microstrip patch antenna.

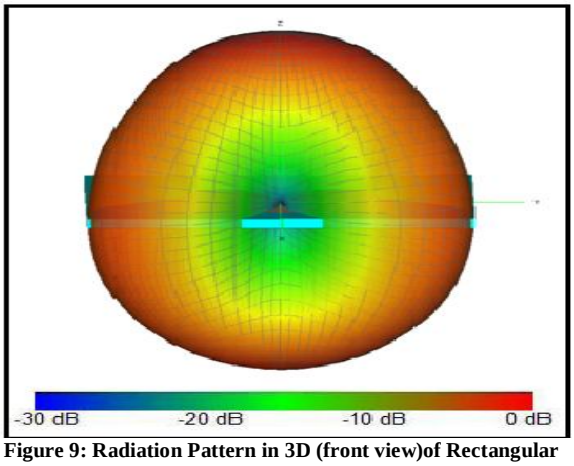


Figure 9: Radiation Pattern in 3D (front view)of Rectangular Microstrip patch antenna.

CONCLUSION

The microstrip antennas has wide range of application because of its obvious and noticeable advantages but the traditional microstrip antennas also have some disadvantages low gain, narrow bandwidth and larger size. In this paper concerning to this disadvantages further few improved areas are mentioned based on the previous work in microstrip antennas. These disadvantages can be minimize with simultaneously balancing all the three parameters by using variety of microstrip antenna topologies, microstrip-antenna-based composite antenna formation and the advanced machining techniques for the microstrip antennas towards the highly integration of antennas for higher frequency. This paper proposes the microstrip antenna overview and recent development of microstrip patch antenna for wide range of application.

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