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A Review Paper of Rectangular Microstrip Patch Antenna

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***Abstract*— Because of their smaller size, microstrip patch antennas are more often utilized in current communication equipment than traditional antennas. In order to design an effective, low profile, small, compatible, and affordable microstrip antenna, authors have used a survey of commonly used techniques and designs found in microstrip antenna papers. These techniques are primarily used to design reconfigurable, multiband, and wideband antennas. Following this, a starter patch design with dimensions is provided, along with the technique that will be used to analyses various antenna parameters.**

***Keywords*— *Microstrip antenna, techniques, wideband, conventional, Directivity, Gain*.**

I. INTRODUCTION

Communication via wireless Due to the increasing need for smaller, more effective antenna systems, antenna design is becoming more and more important. Because of its intrinsic qualities, microstrip patch antennas have recently found widespread usage in satellite communications, the military, aerospace communication, radars, biomedical, and mobile communication.

In the 1950s, microstrip antenna technology was initially shown. But it took over 20 years for this concept to become a reality once printed circuit board (PCB) technology advanced in the 1970s. Since then, because of their evident benefits—light weight, low cost, low profile, planar configuration, ease of conformal, superior portability, suitability for arrays, ease of fabrication, and ease of integration with external circuitry like microwave monolithic integrated circuits (MMICs) and probably all integrated circuits—microstrip antennas have been the most widely used types of antennas.

Because of this, it has a wide range of applications in both civilian and military settings, including television, broadcast radio, mobile systems, RFID, Wi-Fi, Wi-Max, global positioning system (GPS), satellite communications, surveillance systems, vehicle collision avoidance systems, direction finding, radar systems, remote sensing, biological applications like biological imaging, missile guidance, and so forth. Work is still being done on microstrip antennas to find new uses for them by increasing their integration.

Microstrip patch antenna: Electromagnetic waves are the basis for the transmission and reception of antennas. Due to its many advantages over traditional microwave antennas, microstrip antennas find utility in a wide range of real-world scenarios. Figure 1 depicts a microstrip antenna in its most basic configuration. It is composed of a ground plane on one side and a radiating patch on the dielectric substrate ($\epsilon_r \leq 10$).

A conducting (metallic patch on a thin, grounded dielectric substrate) patch of any non-planar or planar shape on one side of the dielectric substrate and a ground plane on the other make up a microstrip patch antenna (MPA). For narrow-band microwave wireless communications that need semi-hemispherical coverage, this printed resonant antenna is used. The microstrip patch antenna has been frequently used because of its easy integration with microstrip technology and planar design. The most basic and widely used microstrip antennas are the circular and rectangular patches. The substrate's thickness, strip width, and dielectric constant all affect the microstrip line's characteristic impedance.

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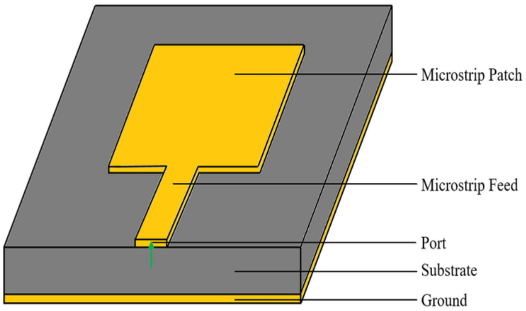

Figure 1: Microstrip antenna with substrate and ground

II. LITERATURE SURVEY

Based on earlier research on microstrip antennas, the literature review of microstrip patch antennas is covered in this part. According to the study, the microstrip patch antenna is a clear choice because of its many notable benefits, which include light weight, low cost, low profile, planar configuration, ease of conformal, superior portability, suitability for arrays, ease of fabrication, and ease of integration with external circuitry. Despite its many benefits, standard microstrip antennas have three main drawbacks: low gain, restricted bandwidth, and relatively large size. These drawbacks frequently have a negative effect on the antennas' efficiency.

One of the primary shortcomings of these kinds of antennas is their limited bandwidth. Increasing substrate thickness is a direct way to increase bandwidth, but it has a number of drawbacks, including decreased efficiency because a significant amount of input power is lost in the resistor, reducing the amount of power that the antenna can radiate. Additionally, while it would seem like a good idea to lower the structure's height, doing so could result in a smaller impedance bandwidth and decreased radiation efficiency.

In order to get small antennas while preserving performance qualities, this is frequently a trade-off. In order to provide wide-impedance bandwidths for microstrip antennas, various other improved techniques have been developed. For example, high permittivity dielectric resonators have been used for microstrip patch antennas, but high permittivity substrates are not a good choice for antenna bandwidth because microstrip antenna bandwidth is best A fraction of the total power available for direct radiation is trapped along the substrate's surface for substrates with low dielectric constants.

In contrast, a three-dielectric layer substrate with a single pin shorted is utilised to increase bandwidth and radiation efficiency without compromising cost or operational benefits. Due to its special qualities, another use of electromagnetic band gap (EBG) structures has garnered a lot of interest in the microwave field in recent years. These periodic structures prevent all electromagnetic surface waves from propagating within a specific frequency range, known as the band gap. This allows for additional control over electromagnetic wave behaviour beyond that which is possible with traditional guiding and/or filtering structures.

Effectively engraved dummy EBG patterns on the feed line joining the two patches of a dual array patch antenna. These fictitious EBG patterns provide a 48.8% increase in bandwidth and are compact and modest in size. By employing an impedance matching circuit, the radiating patch need not be changed in impedance matching, allowing the radiation qualities to be preserved.

Furthermore, the choice of patch substrate has little bearing on the use of the IM method. In a same manner, Ultra WideBand (UWB) may be achieved by constructing slots in microstrip antennas utilising the L, U, T, and inverted T slots in the ground plane.A common type of omnidirectional microwave antenna is the slot antenna.

A single almost rectangular microstrip radiator reactively loaded with an active negative capacitor can be used to provide negative capacitance/inductor high gain. Composite-resonator microstrip antennas employing metamaterial resonators can also be used to add negative capacitance/high gain. Likewise, the low gain of a standard microstrip antenna element is another issue that has to be resolved. Dual patch antenna arrays are an example of an array topology. In general, the phrase "topology optimisation" refers to the broadest category of design optimisation techniques, whereby both the individual components' forms and connections are designed.

The material distribution approach is the most widely used method for topology optimisation. It involves breaking down the design domain into smaller components that collectively depict the device. The cavity backing technique has been used to remove the bidirectional radiation pattern, which allows for higher gain when compared to traditional microstrip antennas. Another method of achieving gain improvement is lens covering.

The radiation beam from the radiator elements is focused by canonical-profile lenses such as hemi-elliptical, elliptical, hyper-hemispherical, and extended hemispherical. When microstrip radiator components and dielectric lens are combined, the integrated microstrip lens antenna may be used as a composite antenna. This is particularly helpful for applications involving high frequencies (mm, sub-mm, terahertz (THz), and optical waves). In multiple-layer dielectric substrate, partial substrate removal occurs.

It is also commonly known that increasing the gain may be accomplished with an antenna array. Similar to this, the last constraint on traditional microstrip antennas is the reduction of their comparatively enormous size, especially at lower microwave frequencies, since the antenna's electrical size determines its operating frequencies. Rectangular microstrip antennas (RMSPAs) should ideally be around half the wavelength of a half guide.

Wheeler and Chu conducted a mathematical analysis of this restriction. With the growing need for ever-smaller wireless communication devices, several attempts have been undertaken to reduce the antenna size and produce an electrically tiny microstrip antenna. One useful technique for reducing the size of microstrip antennas is inductive or capacitive loading.

Composite metamaterial resonators allow for the miniaturisation of microstrip antenna size. Because magnetic substrates offer broader bandwidths than dielectric substrates, magneto-dielectric substrates have been frequently used to miniaturise microstrip antennas. The self-similar patterns that make up fractal geometries (topologies) have created a new avenue for antenna miniaturisation.

It is clear from the talks above that a variety of techniques and materials are employed to enhance the characteristics of microstrip antennas. Nonetheless, there need to be a specific correlation between the microstrip antennas' size, gain, and bandwidth.

According to the earlier research, an increase in one antenna property is typically followed by a decrease in the performance of its other properties.

For instance, when an antenna's size is lowered, its gain and bandwidth are typically sacrificed.

Thus, future advancements in microstrip antenna technology need to be given more careful and balanced thought.

III. PROPOSED ANTENNA DESIGN

The suggested microstrip antenna was designed using the CST programme. where a dielectric substrate has two sides: a ground plane and an emitting fractal on one side. The radiation coming from the antenna is caused by the surrounding fields that are created when the and ground plane work together, as seen in top views of a rectangular radio wire with coaxial feed.

The microstip reception equipment is offered due to its small size and enhanced reference. The recommended receiving apparatus falls neatly within the range of distinct band frequencies due to its resonance frequency.

After these three factors have been optimised, the size of the radiating patch may be determined.

Step 1: Estimate of dimension in term of width (W)

For an efficient radiator, practical width that leads to good radiation efficiencies is:

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Where, μ_0 is the free permeability, ε_0 is the free space permittivity and ε_r is relative permittivity.

Step 2: Assuming a dielectric constant of, the second step is to calculate the effective dielectric coefficient.

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{1/2}$$

Step 3: Calculation of Effective Length (L_{eff})

The effective length is

Step 4: Calculation of Length Extension (ΔL)

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3}{(\varepsilon_{rff}-0.2}$$

Step 5: Calculation of actual Length of Patch (L)

The actual length of radiating patch is obtained by

$$L=L_{\_eff}-2\Delta L$$

Step 6: Calculation of Ground Dimensions (Lg, Wg)

$$L_g = 6h + L \;,\; W_g = 6h + W$$

The simulation results are obtained by treating the ground plane as infinite.

$$Z_{in} = j\,\omega L_p + \frac{R}{1+jQ\,(f_R-\frac{1}{f_R})}$$

With a basic understanding of circuit theory, the input impedance of the patch may be computed as follows: j where f0 is the patch hole's resonance frequency (the resonance frequency of the RLC circuit), and fR= f/f0 defines the frequency ratio.

The design for the suggested microstip antenna is the top and ground layers are crafted from the lossy copper substance, while the substrate is crafted from the FR4 material, which has a dielectric steady worth of 4.4.

FEEDING TECHNIQUES

Microstrip patch antennas can be fed in a variety of ways. Depending on the approach, these techniques can be both contacting and non-contacting. Using a connecting device like a microstrip line, the RF power is directly delivered to the radiating patch in the contacting approach. Power is transmitted by electromagnetic coupling in the non-contacting manner between the radiating patch and the microstrip line. Although there are many other feed mechanisms, the four most often utilised ones are proximity coupling, aperture coupling, coaxial probe (both contacting schemes), and microstrip line (both non-contacting systems).

IV. ANALYSIS FOR RECENT DEVELOPMENTS

This research focuses on minimising the limitations of MSPA by analysing recent efforts on microstrip antennas and a few related approaches. in order to attain significant success with regard to wireless communication. To satisfy the needs of a wide range of wireless applications, including high gain, ultra wide band (UWB), miniaturisation, rectangular, circular polarisation, multipolarization, feeding approaches, etc., the microstrip antenna may be designed with a number of topologies.

The use of various dielectric materials and composite materials to create composite antennas based on composition technology that have higher transmission capacities, lower return losses, higher directivities, etc. In the end, specific matching techniques such as complete impedance matching, micro- and nano-machining methods, and the use of highly integrated and highly operational frequency antennas/arrays are employed.

A). Variety Of Microstrip Antenna Topologies: The appealing features of microstrip antennas have led to their widespread adoption in both military and commercial applications. Nonetheless, the impedance bandwidth of typical microstrip antennas is limited to a few percent, and their dispersed radiation pattern results in omnidirectional radiation, which is plainly unsatisfactory for a variety of wireless applications.

Several microstrip antenna topologies, such as those that are ultra wide band (UWB), miniaturised, circular polarised, high gain, multipolarized, and so forth, have been studied in order to meet the desired requirements. These topologies include various microstrip antenna array element structures and arrangements. When compared to traditional large antennas, microstrip antennas have a lower gain and a smaller bandwidth by design. Certain microstrip antennas with unique topologies—such as quasi-Yagi, planar reflector, UWB microstrip antenna based on the circular topology with stepped block, and material distribution topology optimization—replace the traditional large antennas.

B). Microstrip-Antenna With Composite Formation: When more accurate and precise antenna design is needed, as is the case with missile guidance, satellite transmission, military radars, surveillance, and other special wireless applications, it can be challenging to meet the user-defined, strict performance requirements. For this reason, many antenna designers are concerned about how to improve antenna parameters like gain and bandwidth. .

Due to this challenge, it could be necessary to employ two additional distinct types or structures of antenna components with various attributes. Because multiple types or architectures

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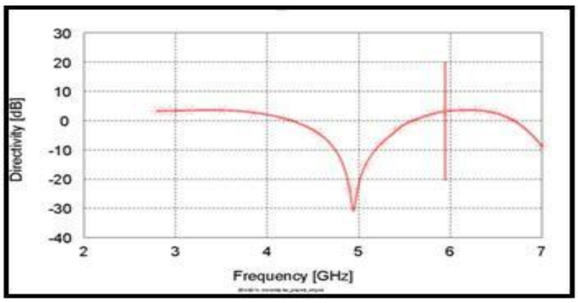
of antennas offer greater advantages, composite antennas made up of two or more types of antennas are especially well-suited for these kinds of applications. For instance, designing a dual-band, dual-polarization antenna for a satellite digital multimedia broadcast (S-DMB) application using a single type of antenna is a difficult challenge.

A quad frequency linearly polarised and dual frequency polarised microstrip antenna using CRLH (Composite Right/Left-Handed) and a dual band circularly polarised ring antenna based on composite right and left handed metamaterials. To meet this requirement, a composite antenna consisting of a linear polarised omnidirectional biconical antenna and a left-handed circularly polarised (LHCP) microstrip antenna is proposed. The composite antenna, which has been widely applied to THz systems, consists of a dielectric lens and microstrip log-period antenna.

C). Advanced Machining Techniques : Microstrip antenna design and manufacturing processes are closely associated in order to provide optimal data transmission, low return losses, and other desired results. The development of a number of machining techniques in recent years, such as complementary metal oxide semiconductor (CMOS), micro-electromechanical systems (MEMS), low-temperature cofired ceramics (LTCC), and multilayer printed circuit boards (MPCB), has created new avenues for the development of novel antennas, including active, reconfigurable, metamaterial-based, and THz antennas.

Microstrip antennas are beginning to operate at reasonably high frequencies and are becoming more and more integrated in terms of the antenna/array and feed network thanks to the development of high-precision, high-speed advanced manufacturing processes. The highly integrated broad-band microstrip antenna array made with MPCB technology is based on sophisticated manufacturing processes. Another uses MEMS technology and is a planar integrated active microstrip antenna for THz waves.

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



- Return loss curve for RMPA:

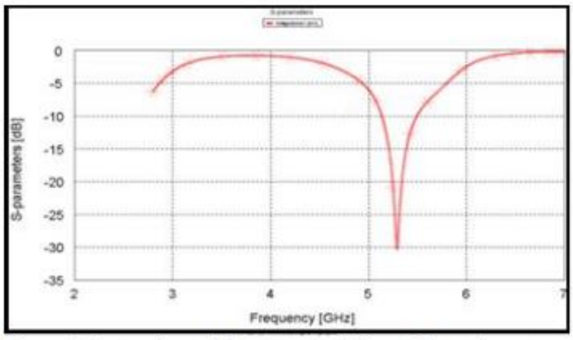


Figure 2: Return loss of Rectangular Microstrip patch antenna with Metamaterial structure.

- Current distribution:

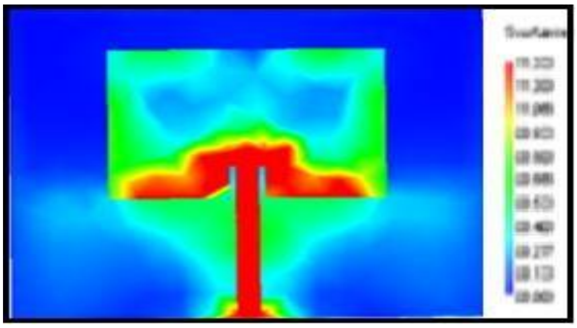


Figure 3: Current Distribution of Rectangular Microstrip patch antenna.

- Directivity for RMPA:

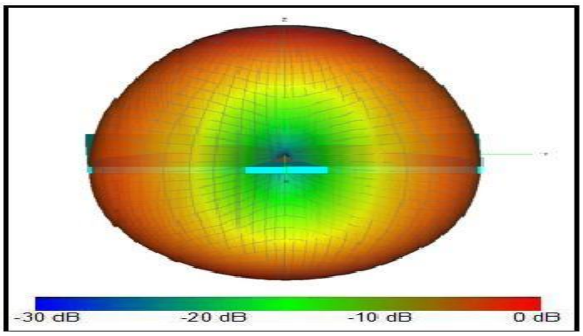


Figure 4: Directivity for RMP antenna.

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• GAIN FOR RMPA :

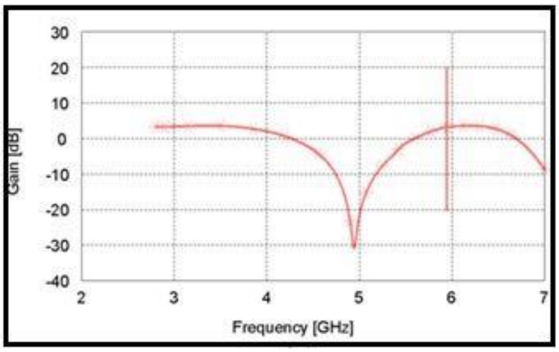


Figure 5: Gain designed for RMPA antenna

RADIATION PATTERN:

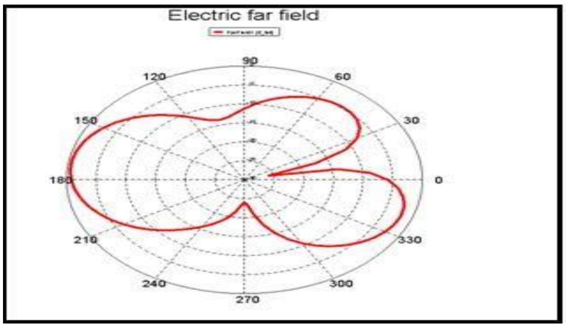
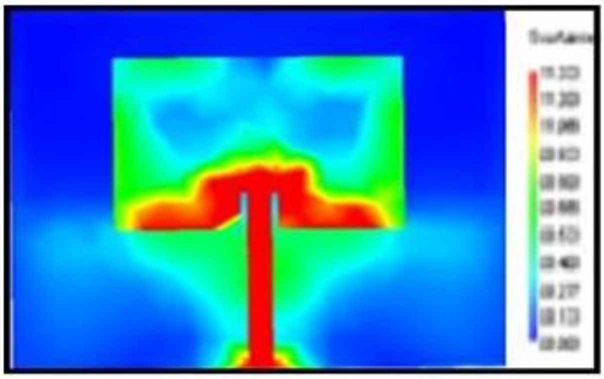


Figure 6: Radiation Pattern of Rectangular Microstrip patch antenna.



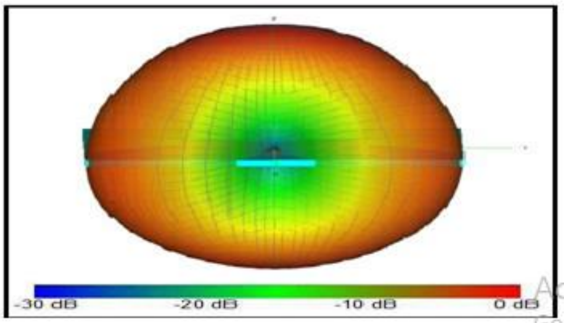


Figure 7: Radiation Pattern in 3D (front view)of Rectangular Microstrip patch antenna.

VI. CONCLUSION

Because of its clear and evident benefits, microstrip antennas are used in a wide range of applications. However, classic microstrip antennas also have significant drawbacks, such as poor gain, restricted bandwidth, and greater size. A few enhanced regions are described in this study in relation to the drawbacks, drawing upon earlier research on microstrip antennas. By utilising a range of microstrip antenna topologies, microstrip-based composite antenna formation, and sophisticated machining techniques for the microstrip antennas towards the highly integration of antennas for higher frequency, these drawbacks can be minimised while simultaneously balancing all three parameters. The overview of microstrip antennas and their latest developments for a variety of applications are presented in this study.

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