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Design and Performance Analysis of 3.1 GHz Microstrip Patch Antenna

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ABSTRACT

Microstrip antennas are one of the most dynamic disciplines of antenna theory, with some innovative work being done in recent years. The growing demand for mobile communication and the advent of emerging technologies necessitate the efficient design of smaller antennas for applications requiring a larger frequency range. The Transmission Feed MPA resonates at 3.1 GHz with bandwidth ranges from 2.9GHz to3.1GHz. Result output shows that VSWR value is nearly '0' at resonant frequency which proves that the antenna is perfect impedance matched. The antenna is having outstanding radiation efficiency of 98.34 % and gain of -33dB.Above value proves that it is a high efficient antenna with maximum radiation in the desired direction only. The antenna is having narrow bandwidth of9.85 and decay factor of '0' which proves that its performance will not change with respect to time.

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Keywords:-Microstrip Patch Antenna, Dielectric, Patch, Solid1, Substrate, Transmission line, VSWR, CST software.

1.INTRODUCTION

Antenna is a transducer that converts electrical to electromagnetic signals. It is derived from the Latin word "Antenna," which means "call." Heinrich Hertz demonstrated that data or information may be sent wirelessly, and Guglielmo Marconi was the first to put it into practise, broadcasting the first radio signal in 1901. Scientist Robert E. Bob Munson (1940-2015) from the United States was the first to create the Microstrip Antenna in 1972. He designed a number of MPAs for various US programmes and persuaded a number of customers to switch from protruding antennas to conformal microstrip antennas. It is a printed antenna that operates at microwave frequencies larger than 1GHz and is well-known for its ease of production on PCB and MCM, small size, low weight, and ease of use.When a patch antenna is activated at a resonant frequency, it creates a strong field inside the cavity and a large current on the bottom surface of the patch, which produces considerable radiation. It has only one reference plane and is made up of four parts: the ground plane, the substrate, the patch, and the feeder. Changes in the form and size of the patch, as well as the permittivity of the material, can be used to calculate the antenna's resonant frequency. The most important Benefits of Microstrip Patch Antennas

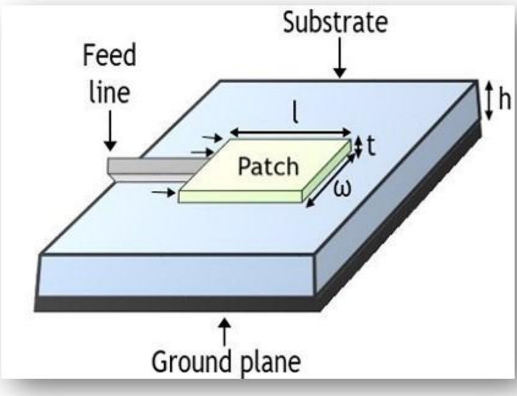
- It's simple to integrate into any active or passive circuit.
- Solid state components can be added directly to the microstrip antenna board, making such circuits compatible with modular designs.
- Feed line and matching networks are produced simultaneously with the antenna construction.

• Because these antennas may be applied directly to a metallic surface on an aeroplane or missile, they can replace bulky and old antennas on aerospace vehicles.
• Because these antennas may be applied directly to a metallic surface on an aeroplane or missile, they can replace bulky and obsolete antennas on aerospace vehicles.
• Linear and circular polarisation can be achieved by changing the feed position.
MPAs have a number of advantages, but they also have certain drawbacks, such as:
• Narrow band-width and low power handling capability
• Practical constraints on maximum gain
• Radiate into half plane and poor radiation performance

A small metallic patch is layered over a big metallic ground layer in a microstrip patch antenna. The patch is supported by a dielectric layer called substrate. Patches are typically engraved on the dielectric substrate using printed circuit board technology. As a result, Printed Antennas is another name for a microstrip patch. The size and shape of the patch affect its performance. A microstrip patch can be fed by a coaxial transmission line or a microstrip transmission line. Together with the patch, the microstrip line can be etched in one step. To reach the right Impedance point on the patch, a recess in the patch is formed. To match the impedance, the recess depth is calibrated to match the impedance.

1.1.ANTENNA DESIGN

As shown in Figure 1, a microstrip patch antenna has a ground plane on one side of a dielectric substrate and a radiating patch on the other. The primary radiator is a rectangular patch. The patch is usually made of conductive metals like copper or gold and can be manufactured into any shape. The substrate's dielectric constant (r) is typically in the range of 2.2<εr <12



2. DESIGN CONSIDERATION

The reason behind the effective length in MPA is when a strong field generated by applying excitation plane waves from the patch attracted towards the ground plane and Waves at the end corner of the patch are traveling to the air and returns to the ground plane, this is also called as the fringing field effect of MPA. Due to this effect radiation occurs and more the fringing field more will be the radiation. The extra length covered by the waves known as ΔL. As the permittivity of air is '1'the effective permittivity is calculated based on it. The design equation of Rectangular type MPA can be calculated by using the following formula. The patch width can be calculated as:

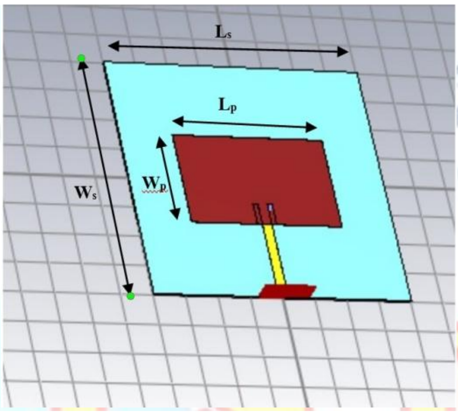


Fig.1. Rectangular MPA

- Calculation of the width(W) :

$$W = \frac{1}{2fr\sqrt{\mu o \varepsilon o}}\sqrt{\frac{2}{\varepsilon r + 1}} = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r + 1}}$$

- Calculation of effective dielectric constant :

$$\varepsilon eff = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left(\frac{1}{\sqrt{1 + \frac{12h}{w}}}\right)$$

- Calculation of extension length:

$$\Delta L = 0.412h\frac{(\varepsilon eff + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon eff - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

- Calculation of effective length:

$$Leff = \frac{c}{2fo\sqrt{\varepsilon eff}}$$

- Calculation of actual length of patch (L):

$$L = Leff - 2\Delta L$$

- Calculation of ground plane dimensions (Lg and Wg):

Lg = 2L
Wg = 2W

- Calculation of Length of the Microstrip transmission line :

$$T\,L = \lambda/4 = \lambda_o/4\sqrt{\varepsilon r}$$

3. DESIGN OF TRANSMISSION LINE

The microstrip antenna is represented by two slots of width W and height h separated by a transmission line of length L in this model. The microstrip is a non-homogeneous line made up of two dielectrics, usually the substrate and air.

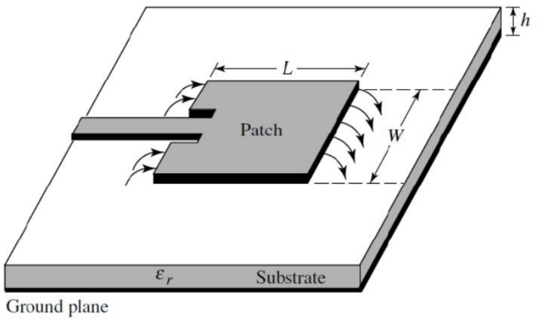


Fig.2. Microstrip Line Feed

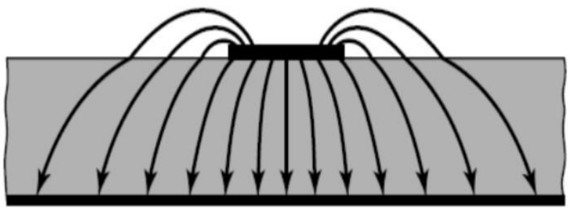


Fig.3. Electric Feild Lines

4. RESULT AND DISCUSSIONS

CST is used to design and simulate the Microstrip patch antenna. In general, this tool evaluates 3D and multilayer architectures. It's been widely employed in the design of many antenna designs. It may be used to calculate and depict return loss, standing wave ratio from Smith charts, Real Power Vs Frequency, VSWR, E-field and H-field distribution, gain, and radiation patterns, among other things.

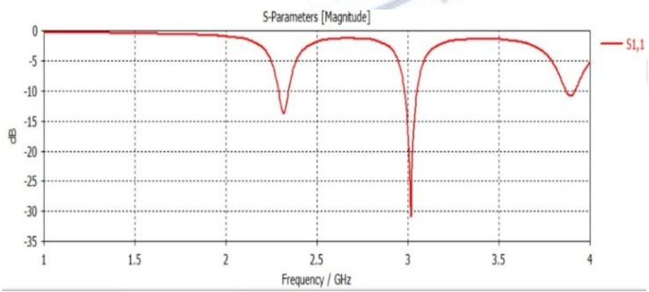


Fig.4. S- Parameter

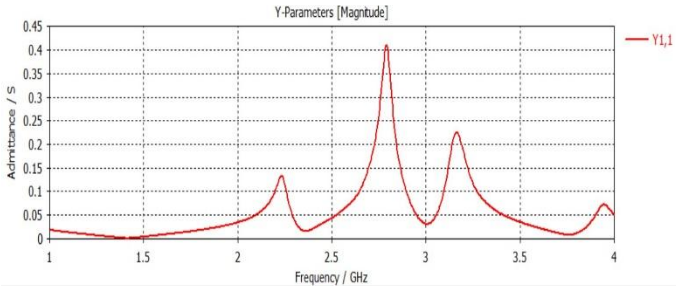


Fig.5. Y- Parameter

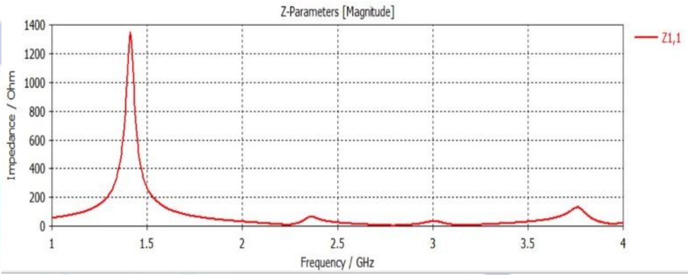


Fig.6. Z- Parameter

VSWR (Voltage Standing Wave Ratio): VSWR (Voltage Standing Wave Ratio) for proposed antenna is nearly0 at frequencies 2.45GHZ and 3.1GHZ,So that the Antenna is perfectly matched.

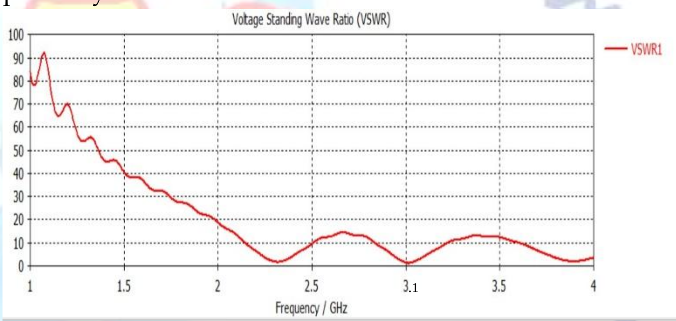


Fig.7. VSWR Curve

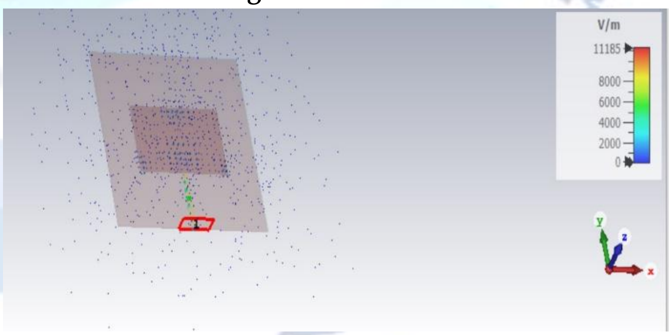


Fig.8. E-Field Distribution

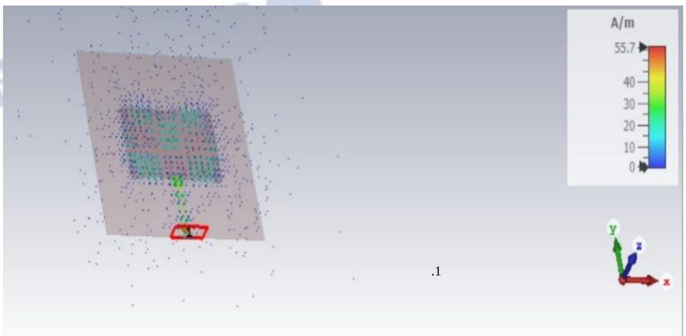


Fig.9. H-Field Distribution

4.1. 3-D Far-Field Radiation Pattern for Directivity and Output Gain:

Gain: An antenna's gain is a critical characteristic. The gain is the ratio of the antenna's radiated field intensity to the reference antenna's radiated field intensity. The direction of highest radiation is referred to as antenna gain, which is commonly stated in decibels (dB). The proposed antenna's gain at 3.1GHz is -32.287dB in this study, as illustrated in Fig.

Directivity: When transmitting or receiving power, it is preferable to maximise the antenna response's emission pattern in a given direction. Similarly, just the geometry of the radiation pattern determines the directivity. As shown in fig.10, the developed antenna achieves a directivity of 7.27dB at 2.5GHz, as illustrated in Fig.10

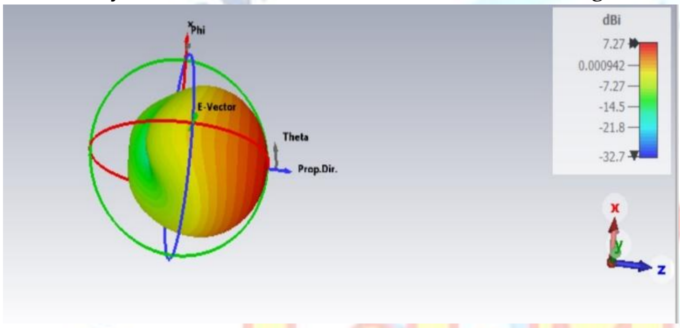


Fig.10. Directivity of Design Antenna

Smith Chart: The proposed antenna's smith chart is shown in Fig.11. It depicts the normalised characteristic impedance in graphical form. For high-frequency circuit applications, the Smith chart is one of the most effective graphical tools.

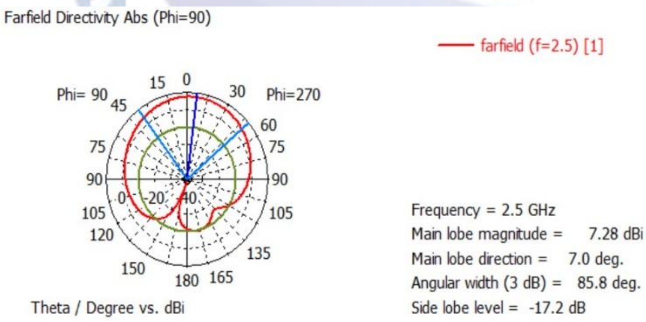


Fig.11. Smith Chart

5. CONCLUSION

In this study, a simple rectangular microstrip patch antenna for use in weather radar, surface ship radar, and various communications satellites is developed and simulated at 3.1GHz using CST Microwave Studio software. The radiation pattern, as well as other important characteristics like gain, efficiency, and loss of return, have all been investigated. Our proposed antenna has a bandwidth of 9.85 and a gain of -32.87dB at 3.1GHz.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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