© October 2023| IJIRT | Volume 10 Issue 5 | ISSN: 2349-6002

Performance Evaluation of Conformal Patch array Antenna on cylindrical surface

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Abstract- The popularity of microstrip antenna arrays has risen in recent times because of their durable structure, being lightweight and cost-effective, yet still delivering impressive performance across a range of uses [1]. And Conformal antennas have many added advantages compared to traditional planar antennas like Flexibility of Design, Improved Aerodynamics, Improved Stealth, Increased Radiation Efficiency etc. The performance evaluation of a conformal patch array antenna on a cylindrical surface involves the assessment of various parameters such as the radiation pattern, impedance bandwidth, cross-polarization, gain, efficiency, and power handling capacity [2]. In this paper we evaluated the performance of the Microstrip Array Antenna by comparing the Gain, Return Loss and the Radiation pattern with Microstrip Antenna. The dimensions of the antenna were calculated then the antenna was built and simulated using the HFSS software, a finite element method.

***Keywords—* Reflection attenuation, radiation pattern, HFSS, gain, return loss.**

I. INTRODUCTION

A conformal microstrip array antenna is a type of antenna that is designed to conform to the shape of a curved surface, making it suitable for use in a variety of applications, including aerospace and defense. This typeof antenna is made up of a number of microstrip elements that are arranged in a specific pattern on a thin substrate. The substrate is then mounted onto a curved surface, allowing the antenna to conform to the shape of the surface [3]. Integrating the antenna also helps to make it lessobtrusive and visually appealing. A microstrip antenna is made up of a radiating patch on one side and a ground planeon the other, with a dielectric substrate in between.

The four main methods of feeding a microstrip patch antenna are edge feeding, probe feeding, aperture coupling and proximity coupling [4]. In our project, we chose edge feeding as it is straightforward to implement and allows the microstrip line and patch to be etched onto the same board. An array antenna is a group of antennas that are connected in a regular pattern to form a single unit. In our project, we combined four patch antennas to form a single array antenna.

Array antennas have several advantages, including increased overall gain, diversity reception, reduced interference from certain directions, the ability to steer sensitivity towards a specific direction, and improved Signalto Interference Plus Noise Ratio by determining the directionof incoming signals. This paper presents a technique for evaluating the performance of a microstrip patch antenna anda microstrip patch array antenna both mounted on a cylindrical surface. The antennas are compared based on their gain, radiation pattern, and return loss to identify the most efficient one.

II. ANTENNA DESIGN AND CONFIGURATION.

A. The consruction of Conformal Micro Strip Antenna

Fig. 1 depicts the construction of a microstrip patch antenna using a feedline feeding approach on a cylindrical surface. Table 1 lists the specifications for the patch. FR4 epoxy substrate, which has a 1.6 mm thickness, a relative dielectric constant of 4.3, and is fed by a 50 ohm microstrip line.

Standard equations are used to determine the patch's dimensions [5].

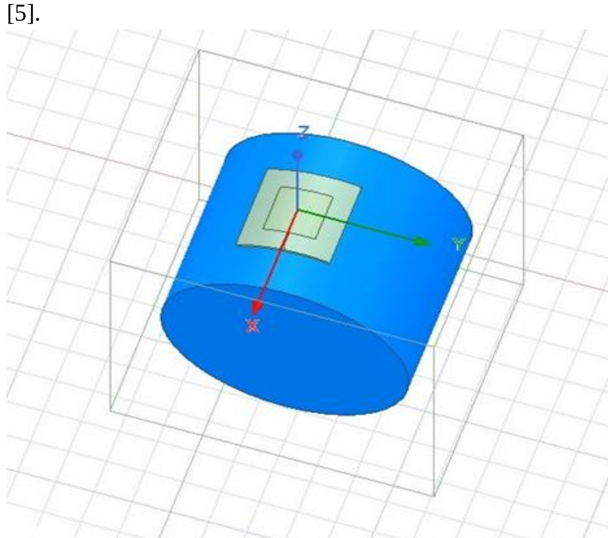


Fig.1: Conformal Micro Strip Patch Antenna (Antenna 1)

Table 1: Antenna Dimensions

Antenna parameters	Patch length	Patch width	Sub_length	Sub_width	Sub_height
Dimensions in mm	28	28	50	50	1.6

A. Proposed Conformal Micro Strip Patch Array Antenna

Fig. 2 depicts the construction of a microstrip patcharray antenna using a feedline feeding approach on a cylindrical surface [6]. FR4 epoxy substrate, which has a 1.6 mm thickness, a relative dielectric constant of 4.3, and is fedwith microstrip line at 50 ohms for four Microstrips patches.Table 1. Dimensions are used for four Microstrip Array Antennas.

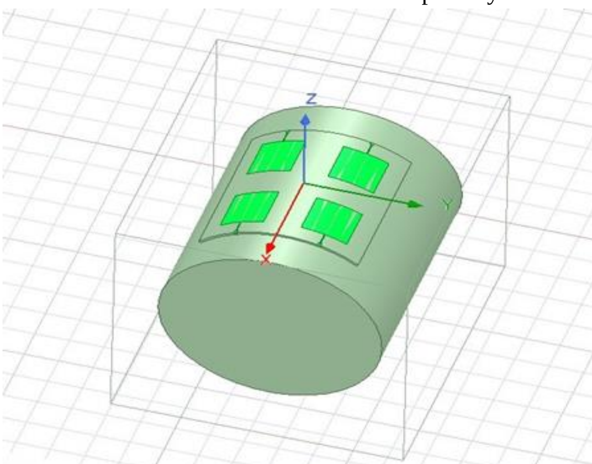


Fig.2. Conformal Microstrip Patch Array Antenna (Antenna 2)

III. Analysis And Simulation

Ansys 2022 R2' is used to simulate the suggested designed antenna. A single patch and an array patch are taken into consideration and utilized as the reference todetermine the parametric change from a conformal micro strip antenna to a conformal micro strip array antenna. An initial simulation is done utilizing a conformal patch antennaand a micro strip feeding system. A thicker ground plane is then used to wrap the micro strip array patch created in the plane surface onto the cylindrical surface. Finally, in order tocompare and reach a conclusion regarding the simulation's goal, we simulate the necessary parameters by appropriately altering the design.

IV. Results And Discussion

A. Comparing the Radiation Pattern of Conformal Microstrip Patch and Conformal Microstrip patch Array Antenna

An antenna pattern, also known as a radiation pattern, is a graphic representation of an antenna's radiation properties as a function of space[7].

Regarding the shape, size, and angle of the radiation, different antennas have varied radiation patterns. The radiation pattern differs for both singular patch antenna and array patch antennas, and the antenna is rated based on its efficiency and maximum radiation pattern.

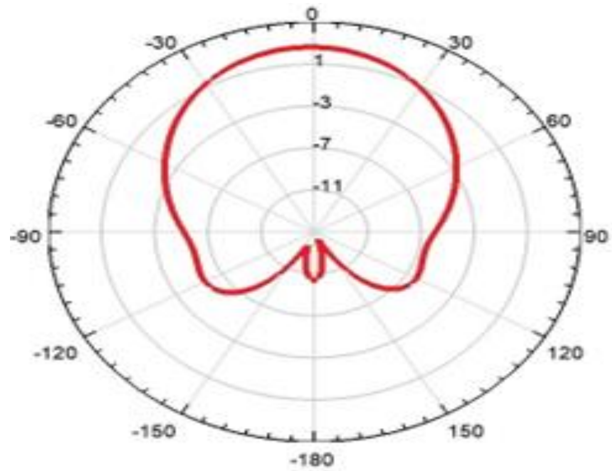


Fig.3. Radiation pattern of Single Patch antenna

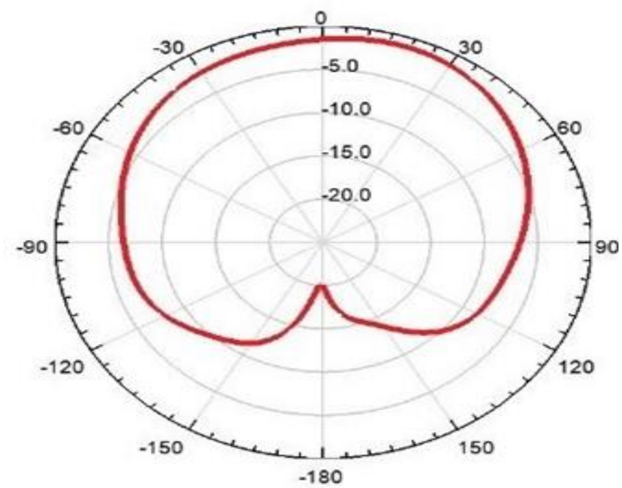


Fig.4. Radiation pattern of Microstrip Array antenna

B. Comparing the Gain of Conformal Microstrip Patchand Conformal Microstrip patch Array Antenna

Measuring the gain of both antennas using simulation and calculation. This is carried out in order to evaluate how successfully the antennas transform input power into radio waves that go in a certain direction [8].

From Fig.5. and Fig.6. we can see that gain of Antenna 2 is high compared to Antenna 1. Having higher gain have many advantages:

- Increased Range: A higher gain antenna can transmit and receive signals over longer distances compared to lower gain antenna.
- Improved signal quality: With a higher gainantenna, the signal-to-noise ratio (SNR) is improved, resulting in clearer and more reliablecommunication.
- Better penetration through obstacles: A higher gain

antenna can penetrate obstacles such as buildings and trees more effectively than a lower gain antenna.

- More efficient use of power: A higher gain antenna requires less power to achieve the same level of performance as a lower gain antenna.
- Reduced interference: A higher gain antenna can reduce interference from other sources by rejecting signals that are not coming from the desired direction.

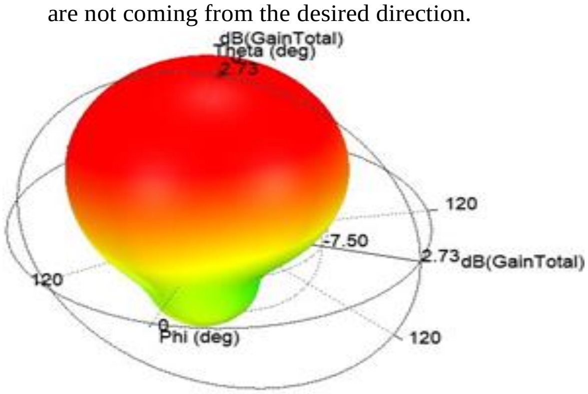
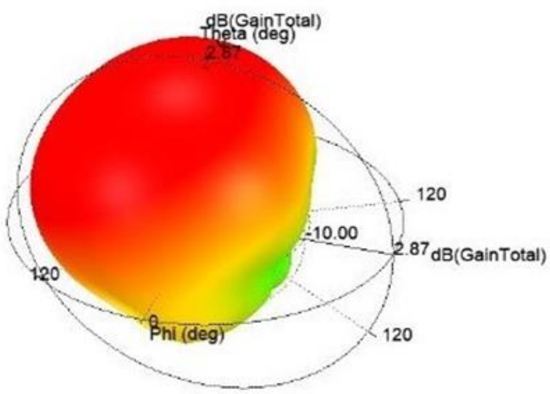


Fig.5. 3D Gain plot of single Patch Antenna



V. COMPARISION TABLE

parameters	Single patch antenna	Array antenna
Return loss	S11(-16.4 dB)	S11(-20.9 dB) S12(-21.8 dB) S13(-25 dB) S14(-30.9 dB)
Gain	2.73 @ (2.4GHz)	2.87 @ (2.345GHz)
Freq range	1-5 GHz	1-5 GHz

Fig.6. 3D gain plot of Microstrip Array Antenna

C. Comparing the Return loss of Conformal Microstrip Patch and Conformal Microstrip patch Array Antenna

The return loss is determined by calculating efficiency, checking the return of incident radiation waves, and counting the waves that the antenna rejects. As a result, return loss is estimated with efficiency increasing as return loss increases.

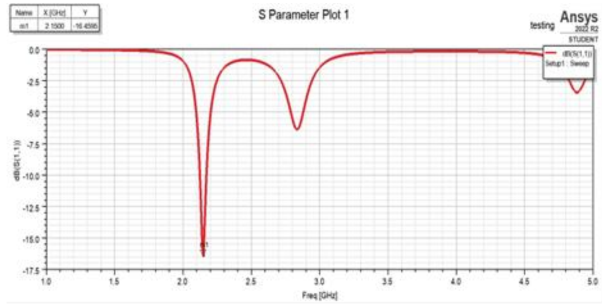


Fig.7. Return loss(S11) of single Patch Antenna

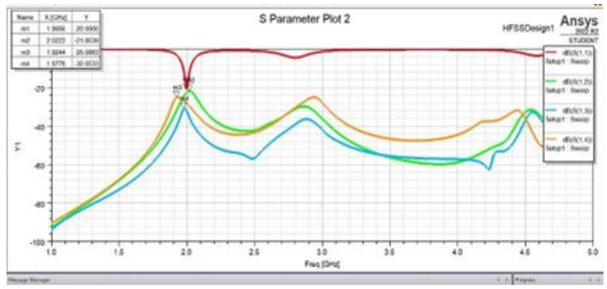


Fig.8. Return loss of Microstrip Array Antenna

VI. CONCLUSION

Through design and analysis, we wish to contrast the conformal patch array antenna with the conventional conformal patch antenna. Radiation pattern, gain, and return loss of an antenna are three factors that are compared.

An antenna with an omnidirectional radiation pattern has been developed. Conformal arrays can only operate at high frequencies in the UHF or microwave range due to the requirement that the elements be tiny. Because of the short wavelength, small enough antennas can be used. They have a significant impact on communication and navigation applications on aeroplanes, ships, and other vehicles.

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