Design Of a Microstrip Circular Patch Antenna At 2.4GHz Using HFSS For WLAN Application

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***Abstract*—A crucial part of any wireless system communication equipment is the antenna. Micro strip antennas are among the most often used types of printed antennas. Many wireless communication systems use microstrip patch antennas, a form of antenna that operates in the microwave frequency range. A ground plate on one side and a radiating patch on the other combine to make a microstrip patch. Their main benefits include directed radiation, light weight, conformal forms, and low cost. The present study involves the construction of a circular microstrip patch antenna, the various parameters of which were analyzed at a frequency of 2.4GHz, appropriate for WLAN applications. The substrate material, FR-4, was selected because it is fire-resistant. The Ansys HFSS program, an incredible tool for antenna design, was used to simulate the task. Additionally, the antenna's optimal gain of 4.40 dB, efficiency of up to 92%, and directivity of up to 6.57 were found, making it appropriate for WLAN applications.**

***Keywords*—Antenna, Microstrip patch Antenna, Circular Microstrip Patch, FR-4, HFSS Software, Gain, directivity**

I. INTRODUCTION

The Internet of Things (IoT) is a cutting-edge technological advancement that makes it possible for devices and sensors to communicate with each other seamlessly over the internet, revolutionizing many facets of industry and daily life. IoT uses integrated sensors and software to link real objects—like cars, appliances, and other commonplace items—so they can share data and work better. IoT has the power to drastically raise living standards and transform industries as it develops further. Antennas play a major role in wireless communication, the technology's fundamental component. Because of their affordability, simplicity, adaptability, versatility, microstrip antennas have become indispensable parts of Internet of Things applications. Efficient and dependable wireless communication is becoming more and more important as the number of Internet of Things devices continues to rise.

The design and optimization of this project is focused on a 2.4 GHz antenna, which is widely used in Internet of Things applications. Using HFSS software and complex computer simulations, the initiative aims to improve key antenna performance metrics, such as gain and Voltage Standing Wave Ratio (VSWR).

II. LITERATURE SURVEY

The RF signals needed to create electromagnetic waves often come from a transmission line, which feeds the patch. Because the patch and substrate form a planar structure, microstrip patch antennas are thin and light. Their lightweight design and easy fabrication make them very suitable for scenarios where weight and space are critical issues.

Microstrip patch antennas are tunable to function at particular frequencies in the microwave range by varying the radiating patch's dimensions and the substrate materials. Because of their adaptability, antennas can be tailored to fit the needs of various wireless communication applications and systems.

V. Prakasam et al.'s 2020 discussion of the design and analysis of several antenna shapes, including triangular, circular, and rectangular ones. The importance of high-gain antennas in WLAN applications is highlighted in the paper's conclusion, along with the parameters for a circular microstrip patch antenna array measuring 2 by 4. The comparison of rectangular and circular patch antennas was covered in [4] in 2015.
In [6], Sonali Katoch et al. talk about the dual-frequency microstrip patch antenna design. Two

slotted patches are joined to the primary rectangular microstrip patch to form the antenna

III. EXISTING WORKS

The existing design model creates a microstrip patch antenna that operates at 2.4GHz using a rectangular patch. FR4, a material with a dielectric constant of 4.4, is used to make the substrate. WLAN and ISM (industrial, scientific, and medical) applications can both benefit from the planned antenna. The antenna is designed using ANSYS HFSS V19, a simulation tool. The created antenna's benefits are its inexpensive cost, easy construction, good isolation, and compact profile. This antenna has a return loss of less than -10dB. Many features, including as radiation pattern, gain, voltage standing wave ratio (VSWR), and return loss, have been examined and simulated.

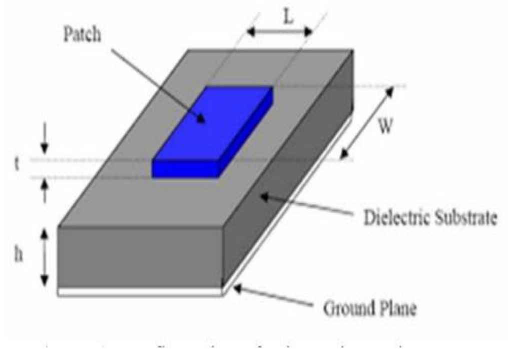

Fig 3.1 Microstrip Patch Antenna Configuration

IV. PROPOSED SYSTEM

A ground plate on one side and a radiating patch on the other combine to make a micro strip patch. The primary benefit of the microstrip antenna is how simple it is to include into WLAN applications. In this work, a circular microstrip patch antenna is built, and its various properties were analyzed at a frequency suited for Internet of Things applications—2.4GHz. The substrate material, FR-4, was selected because it is fire-resistant. The Ansys HFSS program, an incredible tool for antenna design, was used to simulate the task. Additionally, the antenna's optimal gain of 4.40 dB, efficiency of up to 92%, and directivity of up to 6.57 dB were determined, making it appropriate for WLAN applications

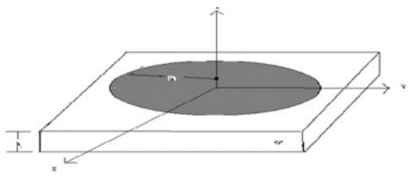

Fig4.1 Structure of Circular Patch

Table 1. Dimensions

Parameters	Values(MM)
Simulation Frequency	2.4GHz
Patch Size	Radius a=17
Length of Substrate	70
Height of Substrate	3.6
Width of Substrate	70
Length of Feedline	29.9
Width of Transmission Line	3
Dielectric constant	4.4

V. METHODOOGY

The suggested measurements for a microstrip patch antenna design that would function at 2.4 GHz in simulation. The patch has a 17 mm radius, making it round. The substrate measures 3.6 mm in height and 70 mm by 70 mm in square dimensions, serving as an insulating layer between the patch and the ground plane. The transmission line measures 3 mm in width, while the feed line, which supplies power to the antenna, is 29.9 mm long. The substrate material's dielectric constant, which is 4.4, affects how electromagnetic waves propagate inside the antenna. These measurements, which include characteristics like gain and impedance, are chosen to guarantee optimal performance at the desired frequency.

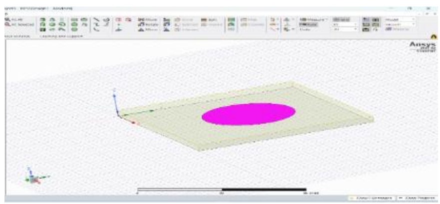

Fig5.1. Side view of designing Circular patch antenna

A feedline is used in a microstrip patch antenna to deliver power from the signal source to the radiating patch, enabling the antenna to transmit or receive electromagnetic waves. The feedline is essential for connecting the antenna to its source or receiver while maintaining optimal performance parameters such as gain, bandwidth, and VSWR (Voltage Standing Wave Ratio).

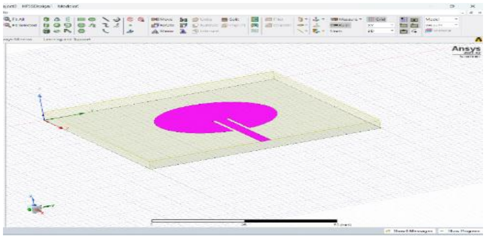

Fig 5.2. Adding feedline

Accurate boundary conditions help simulate the interaction of electromagnetic waves with the materials used (conductors, substrates, etc.). Without proper boundary assignments, the simulation might produce incorrect results, such as improper field distributions, erroneous impedance matching, or unrealistic radiation patterns. By assigning boundaries, you ensure the fields are contained or radiated properly, improving the accuracy of the results.

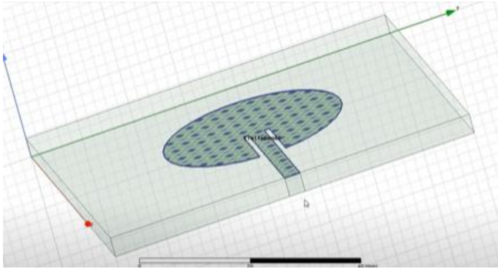

Fig5.3 Side View Showing Finite Conductivity boundary assigned in the design

The radiation box sets the necessary boundary conditions for the simulation. These boundaries act like an infinite space or "free space," where the electromagnetic waves can exit without reflecting back into the simulation. If a radiation box were not created, the software would treat the edges of the simulation domain as reflective, which would disrupt the field distribution and give inaccurate results for antenna performance.

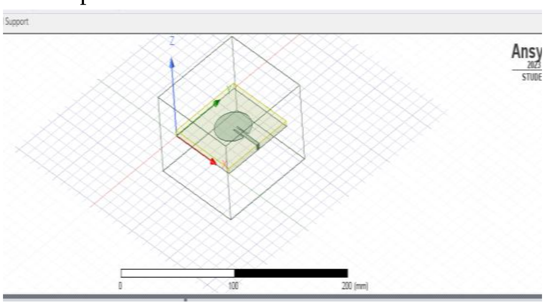

Fig 5.4 HFSS designed circular patch antenna

A number of important design elements, including the Design Settings, 3D Model, Boundaries and Excitations, Mesh Operations, Analysis Setup, Optimetric Settings, and Radiation, are checked, as the validation pane demonstrates.

These checks guarantee that the simulation's configuration is appropriate for additional investigation. The operation labelled “Sweep" in the left sidebar is highlighted and spans from 1 GHz to 3 GHz. This indicates that the frequency sweep for the electromagnetic simulation is also appropriately configured. This thorough validation guarantees that the model is prepared for simulation in order to investigate electromagnetic behaviours, which is usually helpful for designs involving antennas, RF circuits, or microwave components.

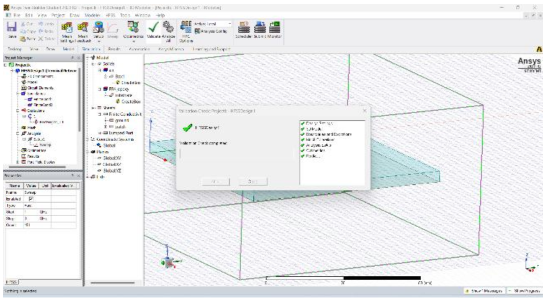

Fig5.5 Validation Check

VI. RESULT

Result or output of the Microstrip Circular Patch antenna is observed in Results where we can obtain S-parameters Plot, Gain, directivity which are followed below:

5.1 S-Parameters:

An alternative to using voltages and currents to express things is to use general waves, or S-parameters. It indicates the amount of wave transmission or reflection from/througha device. with an apparatus such as an antenna.

Return Loss:

Return loss is a symbol for power loss. Transmission line or channel discontinuities are the source of it. As a result, throughout the transmission process, signals are returned.

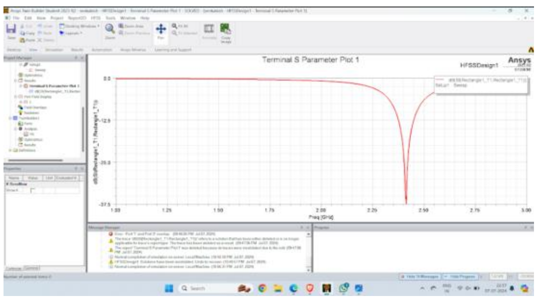

Fig 6.1 S-parameter plot

The aforementioned finding indicates that at the radiated 2.45 GHz frequency, return loss is quite narrow. This suggests that the antenna radiates perfectly. Choose the rectangle plot when creating a terminal solution data report from the results. then choose the function as database and the category as Terminal S-parameter. Next, choose the newly created report

5.2 gain:

This indicates the total power that the antenna radiates. The frequency used determines the maximum radiation that can be produced. Antenna performance is poor if the value obtained is not optimized.

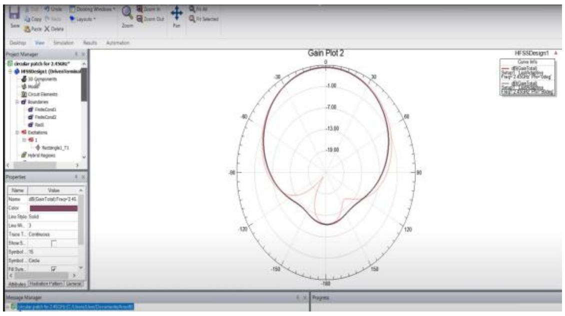

Fig 6.2a. Gain plot1

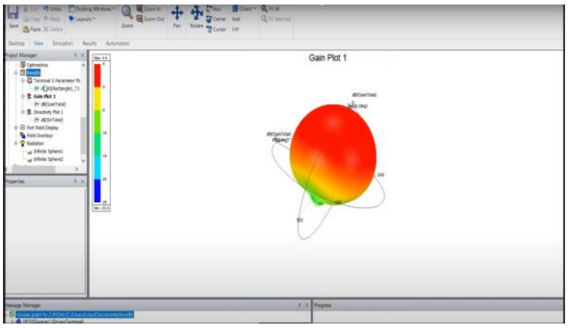

Fig 6.2b. Gain plot 2

5.3 directivity:

The ratio of an antenna's radiation strength in a particular direction to the average radiation intensity across all directions is known as the antenna's directivity.

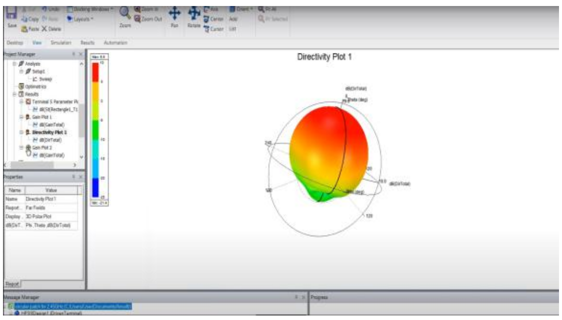

Fig 6.3. Directivity

VII. CONCLLUSION

In summary, the design and analysis of a 2.4 GHz circular patch antenna show promising outcomes for WLAN applications including Bluetooth and Wi-Fi. The antenna is ideal for wireless communication systems because, according to the HFSS calculations, it achieves a resonance frequency of 2.4 GHz with a return loss of -19.7332 dB and a gain of 4.40 dB. Future study will concentrate on building the antenna and testing it in real-world circumstances to assure dependable omnidirectional signal transmission, even though the simulated performance is impressive. In order to improve total antenna performance for modern applications, efforts will also be made to increase signal gain without increasing power consumption, while addressing issues including low efficiency, restricted bandwidth, and power limits

VIII. FUTURE SCOPE

Using HFSS to create 2.4 GHz microstrip circular patch antennas has a wide range of intriguing future applications. These antennas can significantly improve WLAN systems through the incorporation of state-of-the-art design approaches, optimization of critical performance parameters, and investigation of novel use cases. They can also be modified to meet the expanding needs of newly developed wireless communication technologies.

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