

# An Efficient Design Approach for A Circular Microstrip Patch Antenna

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Date of Submission: 05-04-2026

Date of Acceptance: 16-04-2026

**ABSTRACT:** A circular microstrip patch antenna is designed and simulated using CST Microwave Studio for wireless communication applications. Microstrip patch antennas are widely used due to their low profile, light weight, ease of fabrication, and compatibility with integrated circuits. In this paper, a circular patch antenna is designed on a dielectric substrate and analyzed in terms of its performance parameters. The antenna is fed using a suitable feeding technique to achieve proper impedance matching at the desired operating frequency. The design parameters including patch radius, substrate height and feed position are calculated using standard antenna design equations and optimized through simulation. The simulated results show that the proposed antenna resonates at the intended frequency with a return loss less than  $-10$  dB indicating good impedance matching. Other performance characteristics such as VSWR, radiation pattern, gain and bandwidth are also analyzed. The results demonstrate that the designed circular microstrip patch antenna exhibits stable radiation characteristics and satisfactory gain making it suitable for modern wireless communication applications.

**KEYWORDS:** Circular microstrip patch antenna, CST Microwave Studio, Return loss, Radiation Pattern, VSWR

## I. INTRODUCTION

The rapid growth of modern wireless communication systems has increased the demand for compact, efficient and low-cost antennas capable of operating at high frequencies. Among various antenna types, microstrip patch antennas have gained significant attention due to their low profile, light weight, ease of fabrication and compatibility with planar and integrated circuits.

These advantages make microstrip antennas highly suitable for applications such as wireless communication, satellite systems, radar and emerging high-frequency communication technologies

Microstrip patch antennas can be designed in various shapes, including rectangular, circular, triangular, and elliptical geometries. Among these, circular microstrip patch antennas offer advantages such as structural symmetry, compact size and stable radiation characteristics. In addition, circular patch antennas are easier to analyze and are capable of supporting different modes, making them suitable for C-band applications. Their symmetric geometry also helps in achieving uniform radiation patterns and improved impedance matching when properly designed.

The C-band frequency range is widely used in wireless and satellite communication systems due to its balance between coverage, bandwidth and atmospheric attenuation. Antennas operating at frequencies around 6.2 GHz are particularly attractive for high-data-rate communication and compact system design. Accurate modelling and simulation are essential to optimize antenna performance at such frequencies, where electromagnetic effects become more pronounced.

In this paper, a circular microstrip patch antenna operating at 6.2 GHz is designed and simulated using CST Microwave Studio. The antenna is designed on a dielectric substrate and its dimensions are calculated using standard theoretical formulations. The performance of the proposed antenna is evaluated in terms of return loss, voltage standing wave ratio, bandwidth, gain and radiation pattern. The objective of this paper is to analyze the feasibility of a circular microstrip patch antenna for C-band wireless communication applications and to demonstrate the effectiveness of CST Microwave Studio as a design and analysis tool

## CIRCULAR MICROSTRIP PATCH ANTENNA:

A circular microstrip patch antenna is a type of planar antenna in which a circular metallic radiating patch is printed on one side of a dielectric substrate, while a ground plane is placed on the

opposite side. Microstrip patch antennas are widely used due to their compact size, low profile, light weight and ease of fabrication. The circular geometry provides structural symmetry, which results in stable radiation characteristics and improved impedance matching. Due to these advantages, circular microstrip patch antennas are extensively used in C-band wireless, satellite and radar communication systems.

### **CST MICROWAVE STUDIO:**

CST Microwave Studio is a three-dimensional full-wave electromagnetic simulation software widely used for the design and analysis of high-frequency components such as antennas and RF devices. It employs numerical techniques to accurately predict electromagnetic behaviour. In this paper, CST Microwave Studio is used to model the circular microstrip patch antenna and to analyze key performance parameters including return loss, VSWR, gain, bandwidth and radiation pattern, ensuring reliable and optimized antenna performance.

### **RETURN LOSS:**

Return loss is a measure of the amount of power reflected back from the antenna due to impedance mismatch between the antenna and the feeding transmission line. It is represented by the S11 parameter. A return loss value lower than -10 dB indicates good impedance matching, resulting in efficient power transfer from the source to the antenna. In antenna design, achieving low return loss at the operating frequency is critical for optimal performance.

### **VSWR (Voltage Standing Wave Ratio):**

Voltage Standing Wave Ratio (VSWR) is a parameter that indicates the effectiveness of impedance matching between the antenna and the feed line. A VSWR value close to 1 represents ideal matching, while values below 2 are generally acceptable for practical applications. Lower VSWR values indicate reduced reflected power and improved radiation efficiency of the antenna.

### **RADIATION PATTERN:**

The radiation pattern of an antenna describes the spatial distribution of radiated electromagnetic energy. It provides information about the antenna's directional characteristics, beamwidth and coverage area. Circular microstrip patch antennas typically exhibit a broadside radiation pattern, making them suitable for wireless communication systems that require uniform coverage in a specific direction.

### **GAIN:**

Antenna gain is a measure of the antenna's ability to direct radiated power in a particular direction compared to an isotropic radiator. It accounts for both the directivity and efficiency of the antenna. Higher gain improves signal strength and communication range, which is essential for reliable wireless communication systems operating at high frequencies.

## **II. LITERATURE SURVEY**

This literature review presents a comprehensive overview of previously published work related to circular microstrip patch antennas. Several researchers have investigated circular microstrip patch antennas because of their structural symmetry and stable radiation characteristics. Compared to rectangular patch antennas, circular patches offer simpler theoretical analysis and improved impedance matching when properly designed. Studies have shown that circular microstrip antennas are well suited for C-band applications due to their compact dimensions and ability to operate efficiently at higher frequencies. Different feeding techniques, including microstrip line feed, coaxial probe feed and aperture coupling, have been explored in the literature to improve impedance matching and radiation efficiency. Among these methods, coaxial probe and microstrip line feeding are widely preferred due to their simple structure and ease of implementation. Researchers have demonstrated that the feed position plays a critical role in controlling return loss and VSWR of circular microstrip patch antennas. Simulation tools such as CST Microwave Studio, HFSS and FEKO have been widely used for the design and analysis of microstrip antennas. CST Microwave Studio, in particular is favoured for its accurate full-wave electromagnetic solvers and userfriendly modelling environment. Several studies have reported that CST provides reliable prediction of antenna parameters such as return loss, gain, bandwidth and radiation patterns, which closely match measured results. Recent research has focused on optimizing microstrip patch antennas for higher frequency bands by modifying patch dimensions, substrate properties and feeding techniques. Techniques such as parametric analysis, substrate selection and geometric optimization have been employed to achieve better impedance matching and enhanced performance. However, achieving compact size with stable radiation characteristics at C-band frequencies remains an active area of research. Based on the review of existing literature, it discusses different design methodologies, fabrication techniques, performance enhancement methods and

comparative studies conducted by various researchers

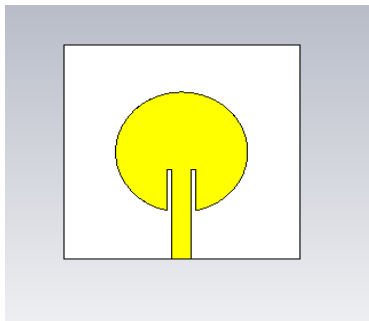
### III. PROPOSED WORK

In this paper, a compact circular microstrip patch antenna (CMPA) is proposed for improved performance at the desired resonant frequency. The objective of the proposed design is to achieve optimized return loss, enhanced gain and improved radiation efficiency while maintaining a simple and cost-effective fabrication process.

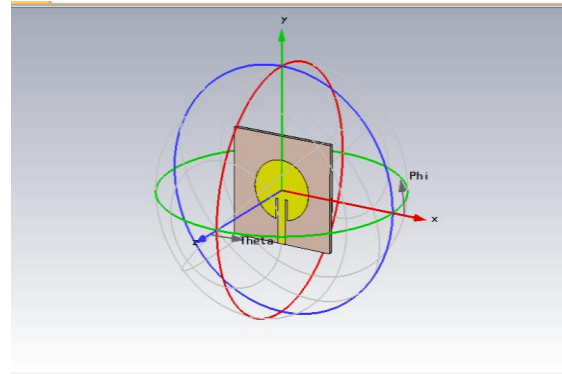
The antenna dimensions, including patch radius, substrate thickness and dielectric constant are initially calculated using standard theoretical equations for circular microstrip patch antennas. These calculated parameters are further refined through parametric optimization in CST Microwave Studio to achieve resonance at the desired operating frequency.

A microstrip line feeding technique is employed to excite the antenna. This feeding method is selected due to its planar structure and compatibility with integrated circuits, making it well suited for modern wireless communication systems. The width and length of the microstrip feed line along with its position relative to the circular patch are optimized to achieve proper impedance matching. The design aims to minimize return loss and ensure a VSWR value below 2 at the operating frequency.

The results obtained from simulation are used to demonstrate that the proposed microstrip line-fed circular microstrip patch antenna offers satisfactory gain, stable radiation characteristics and efficient performance while maintaining a compact and low-profile structure. This work confirms the suitability of the proposed antenna design for integration into modern C-band wireless communication systems.



**Fig.1. Geometry of the Circular Microstrip Patch Antenna**



**Fig.2. Simulation and fields of circular microstrip patch antenna**

Fig.1 shows the top view of the proposed circular microstrip patch antenna. The circular patch acts as the radiating element, while the connected strip represents the microstrip feed line used to excite the antenna. The structure is printed on a dielectric substrate with a ground plane on the opposite side.

Fig.2. illustrates the 3D radiation pattern of the proposed circular microstrip patch antenna. The coloured lobes represent the radiation intensity in different directions, showing that the antenna radiates predominantly in the broadside direction (normal to the patch surface). The  $\theta$  (theta) and  $\phi$  (phi) planes indicate the angular distribution of radiation in spherical coordinates.

This pattern confirms that the antenna exhibits stable and nearly directional radiation characteristics suitable for wireless communication applications.

### IV. SIMULATION AND RESULT

The proposed circular microstrip patch antenna is designed and simulated using CST Microwave Studio to evaluate its performance for C-band wireless communication applications. The antenna is analyzed over a suitable frequency range around the target operating frequency of 6.2 GHz. Key performance parameters such as return loss, VSWR, bandwidth, radiation pattern and gain are obtained from the simulation results.

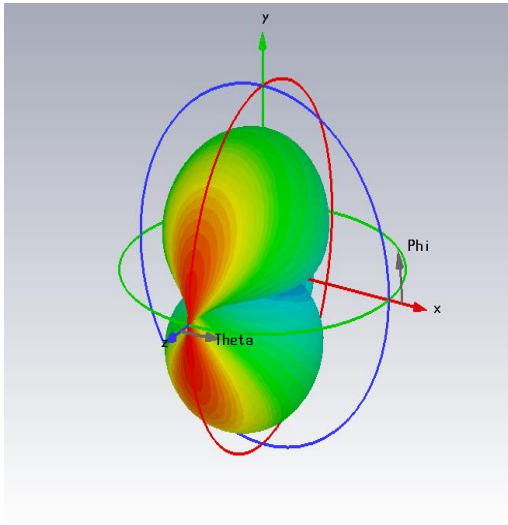


Fig.3

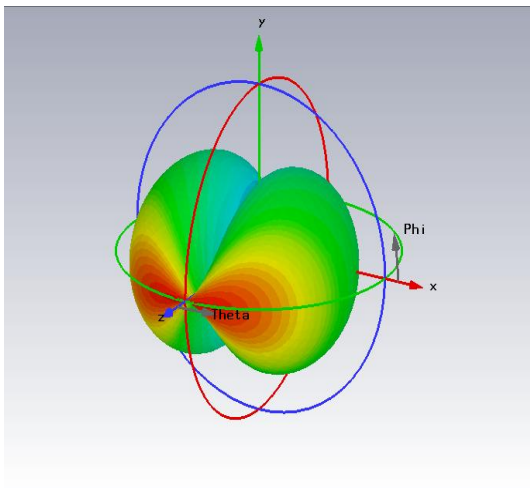


Fig.4

Fig.3, Fig.4. Represent the radiation pattern for circular microstrip patch antenna

Fig.3. and Fig.4. show the 3D radiation patterns of the proposed circular microstrip patch antenna in different angular planes. The coloured regions represent the radiation intensity, where red indicates maximum radiation and blue/green indicate lower radiation levels. The radiation pattern exhibits a broadside characteristic, with maximum radiation directed normal to the patch surface. The shapes in the  $\theta$  (theta) and  $\phi$  (phi) planes confirm stable and directional radiation behaviour, making the antenna suitable for wireless communication applications at the operating frequency.

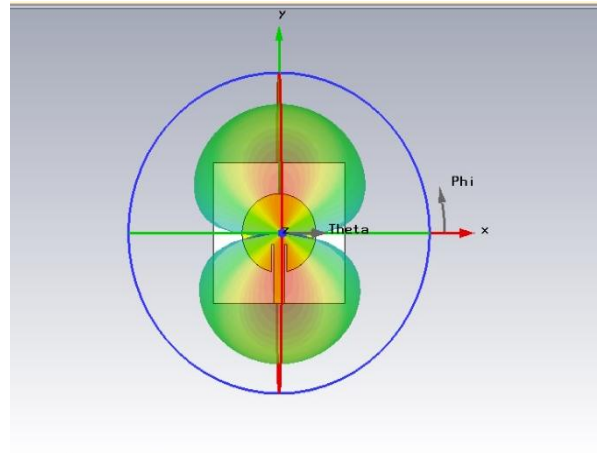


Fig.5. Proposed circular microstrip patch antenna and its radiation pattern

Fig.5. shows the 2D radiation pattern of the proposed circular microstrip patch antenna in a specific angular plane. The coloured regions represent the radiation intensity, where red indicates maximum radiation and green/blue indicate lower radiation levels. The pattern demonstrates a broadside radiation characteristic, with maximum radiation directed perpendicular to the surface of the patch. This confirms that the antenna provides stable and directional radiation at the operating frequency.

S.NO	PARAMETER	VALUE
1	Return Loss	-35dB
2	VSWR	1.04
3	Resonant Frequency	6.0GHz
5	Radiation Efficiency	-3.4 dB
6	Total Efficiency	-5.8 dB
7	Directivity	~6.3 dBi
8	Gain	~0.6 dB

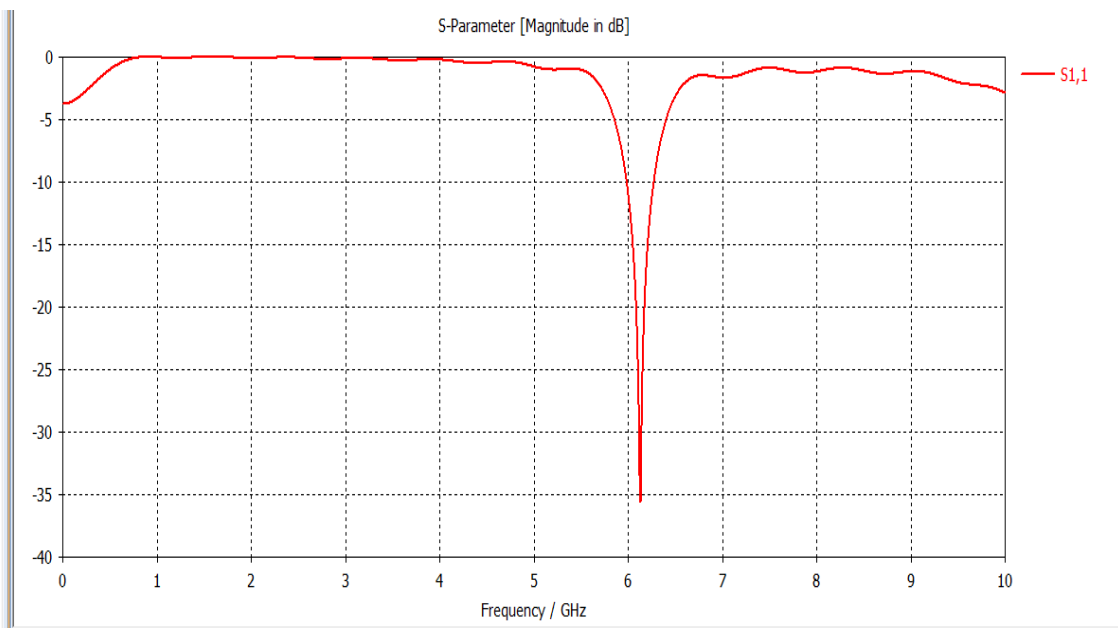
Table1.1 shows the simulation output parameter list for proposed patch antenna

S.NO.	PARAMETER	VALUE
1	Patch Radius	7mm
2	Substrate Height	1.6mm
3	Dielectric Constant	1.44
4	Patch Thickness	0.035
5	Ground Plane Dimension	25mm×25mm
6	Line Impedance	50
7	Feed Width	3mm
8	Tangent Loss	0.02
9	Lower Frequency	2GHZ
10	Higher Frequency	10GHZ

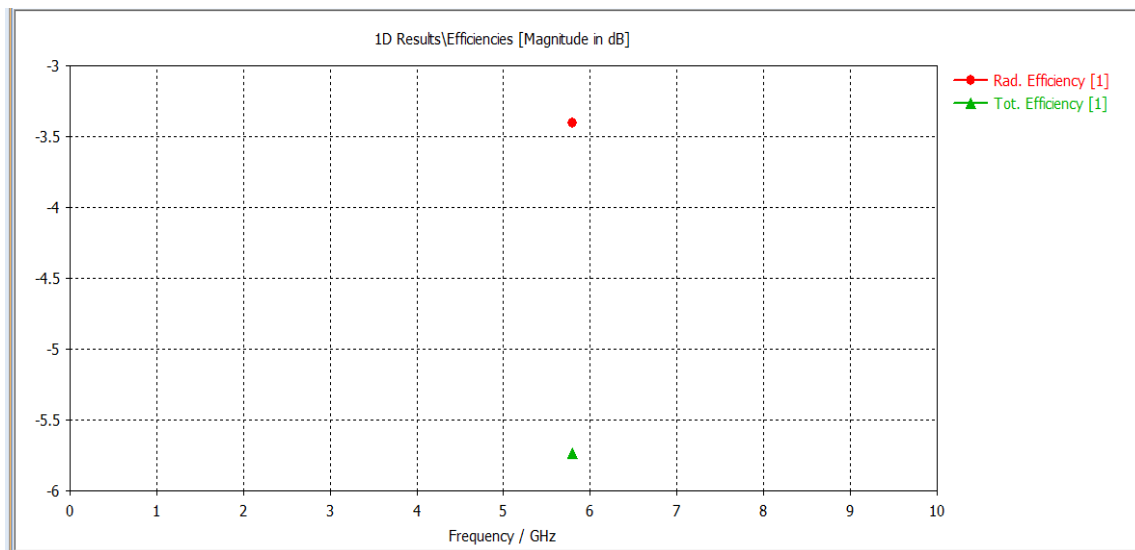
**Table 1.2. Design parameter for circular microstrip patch antenna**

Table 1.1. shows the simulation output parameter list for proposed patch antenna. Table 1.2. shows the design parameter list for proposed circular microstrip patch antenna.

Fig.6. shows the simulated S-parameter ( $S_{11}$ ) characteristics of the proposed circular microstrip patch antenna. A deep return loss of approximately  $-35$  dB is observed around 6 GHz, indicating good impedance matching at the resonant frequency. Since the  $S_{11}$  value is well below  $-10$  dB at resonance, the antenna exhibits efficient power transmission with minimal reflection. Fig.7. presents the radiation efficiency and total efficiency of the proposed circular microstrip patch antenna at the resonant frequency. The radiation efficiency is approximately  $-3.4$  dB, while the total efficiency is around  $-5.8$  dB near 6 GHz. These results indicate that the antenna effectively converts input power into radiated power, with acceptable losses due to dielectric and conductor effects



**Fig.6. S-parameter for circular microstrip patch antenna**



**Fig.7. Efficiencies for circular microstrip patch antenna**

## V. CONCLUSION

In this paper, a circular microstrip patch antenna designed to operate at 6.2 GHz has been presented and analyzed using CST Microwave Studio. Since the operating frequency of 6.2 GHz lies within the C-band range, the proposed antenna is suitable for C-band wireless communication applications. The antenna geometry and dimensions were calculated using standard design equations

The simulated results show that the antenna achieves good impedance matching at the operating frequency, with a return loss less than  $-10$  dB and a VSWR value below 2, indicating efficient power transfer between the feed line and the antenna. The radiation pattern obtained from the simulation exhibits stable broadside radiation with symmetrical characteristics, which is desirable for reliable wireless communication. In addition, the antenna provides satisfactory gain and bandwidth while maintaining a compact size, low profile, and simple structure.

Based on the simulation results, it can be concluded that the designed circular microstrip patch antenna meets the essential performance requirements for C-band wireless communication systems. The study also demonstrates that CST Microwave Studio is an effective and reliable tool for the design and performance evaluation of microstrip patch antennas. Therefore, the proposed antenna design is suitable for practical implementation in C-band wireless communication applications. Future work may involve experimental validation and

further optimization to enhance gain and bandwidth performance.

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