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# DESIGN AND ANALYZE CIRCULAR SHAPED MICROSTRIP PATCH ANTENNA FOR C APPLICATION

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**Abstract:** This paper provides an in-depth overview survey on the development and evaluation of circular-shaped planar patch antennas for C-band applications, which span frequencies typically from 4 to 8 GHz. Owing to their small dimensions, slim form factor, and easy for integrating with planar and non-planar surfaces, CPA (circular patch antennas) have become a common choice in today's wireless communication systems, radar, and satellite technologies. The literature explored highlights key design methodologies, simulation tools, and enhancement techniques that enhance antenna essential represented by attributes such as return loss, gain, bandwidth, and radiation efficiency. Various substrate materials, feeding mechanisms, and structural modifications like slots and parasitic elements are also reviewed to understand their impact on the operational bandwidth and directivity. This survey aims to provide insights into the current advancements and challenges in circular patch antenna design specific to the C-band, offering a foundation for future R&D in this domain.

**Index Terms –** Circular patch antenna, C-band, microstrip antenna, antenna design, bandwidth enhancement, return loss, gain optimization, radiation pattern, substrate material, electromagnetic simulation.

## I. INTRODUCTION

The rapid advancement in wireless/cordless communication has resulted in the need for the progress of compact, efficient, and high-performance antennas. Among various antenna configurations, MPA(microstrip patch antenna) are widely adopted owing to their compact form, low mass, manufacturability, and compatibility with integrated circuits. Within this category, circular-shaped patch antennas are most compatible for their symmetrical radiation patterns, ease of impedance matching, and suitability for circular polarization. The C-band operates within the frequency (typically 4–8 GHz) is a key factor in wide range of uses such as satellite communications, weather radar, terrestrial microwave links, and military systems. Designing antennas that operate efficiently in this frequency band is crucial for ensuring reliable and high-speed data transmission. Circular patch antennas, when designed appropriately, can offer desirable characteristics like moderate gain, broad bandwidth, and stable radiation performance, making them well-suited for C-band applications. This literature survey aims to explore existing research focused on the design, simulation, and optimization of circular-shaped patch antennas specifically tailored for C-band operation. The paper reviews different design approaches, substrate materials, feeding techniques, and structural modifications employed to enhance key critical antenna factors such as return loss, gain, bandwidth, and radiation efficiency. Through this survey, we identify current trends, challenges, and future research opportunities in the field in the context of circular microstrip antennas for C-band applications.

## II. LITERATURE SURVEY

The study by Sonu Pandey and Karuna Markam looks at the development and simulation related to a CMPA (circular microstrip patch antenna) made to work in the C-band frequency range, especially around 5 GHz. They used FR4 epoxy as the underlying material having a permittivity of 4.4 and measuring a width of 1.6 mm. The antenna design and testing were done using Ansoft HFSS v13 software, which is utilizes on the FEM (finite element method) for electromagnetic simulations. The antenna was tuned to work at 5.026 GHz and showed a return loss of -38.09 dB, meaning it had very good impedance matching. It had a signal frequency span of 190.5 MHz (3.79%), a directivity of 4.5 dB, a amplification of 2.66 dB, achieving a radiation efficiency of 59.1%. The emission pattern indicates that the majority of the signal is directed forward, with minimal back radiation, making it useful for directional communication. In conclusion, the study showing that the antenna works well for satellite and transponder application in the C-band because of its good performance and focused signal direction.

  

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The paper by Nidhi M. Thaker and Vivek Ramamoorthy gives an overview of different design methods to boost the operational effectiveness related to CMPA(circular microstrip patch antennas) designed for C-band uses. The authors explain how different slot shapes—like L-slits, diamond slots, and C-shaped coupling slots—can help increase bandwidth, reduce return loss, and boost gain. These changes are made to make CMPAs work better for systems like satellite communication, WiMAX, WLAN, and Wi-Fi. The paper highlights how these design improvements are important to address the demands of current wireless/cordless communication systems operating in the C-band.

In their research, Divesh Mittal, Aman Nag, and Ekambir Sidhu designed a minimized MPA(microstrip patch antenna) for the C-band operates within the frequency (4 to 8 GHz) using tool (CST Studio Suite 2016). The antenna was built using FR4 substrate featuring a specific permittivity of 4.4 and having a thickness measuring 1.57 mm. To improve performance, they modified the traditional patch by adding rectangular slots at the upper edge for lowering the tuned frequency and included a smaller slot within the patch to increase bandwidth. These changes resulted in a 10.12% size reduction compared to a standard rectangular patch antenna. The final design showed strong performance with a wide bandwidth as high as 2.65 GHz and an excellent signal loss due to reflection of -60.29 dB. As a result of its simple configuration, compact form factor, and operational efficiency, the antenna is ideal for diverse wireless applications, including ISM band use, maritime defense, and aeronautical communication systems.

A research team from Vignan's Institute of Information Technology in Visakhapatnam—J. Siddartha Varma, P. Sowmya Deepika, P. Satya Sreeja, V.S.S. Chandra Sekhar, and T. Harish Sai Reddy—created an innovative CMPA (circular microstrip patch antenna) for C- band wireless applications. The antenna is built on an FR-4 substrate sized 23 mm × 23 mm with a width of 0.8 mm and incorporates a partial reference plane to enhance bandwidth. Through careful design adjustments, it achieves a wide 4 GHz bandwidth and operates mainly at 6.2 GHz. It also supports circular polarization with a 700 MHz axial ratio bandwidth. With a steady gain of 2.69 dB across its frequency range and well-formed radiation patterns, the antenna is suitable for reliable and efficient wireless communication within the C-band.

Chaitali Mukta, Mahfujur Rahman, and Abu Zafor Md. Touhidul Islam from the University of Rajshahi, Bangladesh, developed a compact circular antenna for WLAN applications, operating in the 5.15 to 5.825 GHz . The antenna is built on FR-4 material having a thickness of 1.4 mm and uses a microstrip conductor for signal feeding. To decrease the size and improve performance, a circle shaped cuts was incorporated into the patch, while a square shaped cuts was introduced in the reference plane. The antenna showed strong performance at 5.5 GHz, offering a large frequency of 702 MHz, a low measured loss of reflection of –31.58 dB, providing a amplification of 3.23 dB, a directional of 4.28 dBi, and about 79% efficiency. These features make it a suitable option for WLAN communication.

In their study, A. Manimegalai and Dr. I. Kalphana designed a small rectangular MPA(microstrip patch antenna) suitable for C- band satellite communication at 4.3 GHz. The antenna utilizes FR4 as its substrate material having a permittivity of 4.4 and a thickness of 1.6 mm, and it measured only 25 mm by 30 mm. Virtual work was conducted with Ansys HFSS software, showing achieving a return loss of −19.79 dB (indicating low signal reflection), a bandwidth of 0.1806 GHz (covering 4.2831 GHz to 4.4637 GHz), and a gain of 2.54 dB. Results confirm that the antenna is both compact and efficient, making it appropriate for C-band satellite communication.

A group of researchers—Md. Mahbubur Rahman, Mohammad Rabiul Islam, Md. Gazi Salah Uddin, and Md. Monirul Islam— developed a circular patch antenna featuring an innovative aspect: a small "bridge" connecting the main patch to the ground layer. This clever design facilitates wideband operation of the antenna from 4.96 GHz to 14.55 GHz, covering the C-band, X-band, and parts of the Ku-band. Built using affordable FR4 material featuring a permittivity of 4.4 and a width of 1.6 mm, the antenna showed return loss values below −10 dB throughout the entire range, indicating efficient signal transmission with minimal reflection. Its compact size and simple construction make it suitable for a variety within current wireless communication systems.

Asad Ali Khan, Zhenyong Wang, Dezhi Li, and Ali Ahmed developed an advanced eight-port antenna array tailored for 5G smartphones and similar handheld devices. The design supports MIMO (multiple-input multiple-output) technology, which enhances wireless performance by enabling multiple data streams. The antenna consists of three layers: the top layer incorporates eight small circular elements for signal processing, while the middle layer is made of cost-effective FR-4 material, followed by the bottom layer serves as the ground with four specially shaped slots that improve performance. Each element is connected with 50- ohm connectors, and a neutralization line is added between feed paths to minimize signal interference, improving efficiency and isolation. The antenna operates from 3 GHz to 4.2 GHz, covering key 5G bands such as n77 and n78. It achieves strong port isolation, a low envelope correlation coefficient (ECC), with a maximum gain of around 4 dB. Both simulations and physical tests confirmed the antenna's effective performance, making it suitable for next-generation 5G devices, including those following O- RAN standards.

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The paper by Nallanthighal Srinivasa Raghava presents a recently developed CMPA(circular microstrip patch antenna) with three concentric rings on the patch, intended to improve performance for white space communication systems. Built on a low-cost FR4 material substrate with defined dielectric properties of 4.4 and a width of 1.6 mm, the antenna shows wide bandwidth and enhanced radiation characteristics based on simulation results. Its reduced size and easy fabricate was a practical choice for use in cognitive radio and white space communication systems.

The paper by V. Harsha Ram Keerthi, Dr. Habibullah Khan, and Dr. P. Srinivasulu focuses on A 5 GHz rectangular MPA(microstrip patch antenna) for C-band radar systems, developed like wind profiler radar. The antenna was designed using the IE3D electromagnetic simulator, with a 50-ohm microstrip line feed and an FR4 substrate . The objective was to address common limitations such as narrow bandwidth and low gain. Simulation results showed improved bandwidth and gain, indicating that the space-efficient design is well-suited for efficient radar systems. In their study, M. Meena and P. Kannan from PET Engineering Institution, India, explored how different shapes and materials affectthe efficiency of MPA(microstrip patch antennas), which are popular in wireless communication Because of their lightweight and cost-effective nature, and ease of manufacture. While these antennas offer many benefits, they often face the challenge of limited bandwidth. To improve this, the researchers designed antennas in four different shapes and tested them using Multiple substrate types with diverse dielectric properties. Conducting simulations with ADS simulation software, they assessed how each design variation influenced key performance factors such as gain, bandwidth, return loss, and directivity. The study emphasizes how careful choices in antenna shape and substrate material can greatly enhance overall antenna performance.

The paper by K. Leena and P. Ashvika from PES Engineering College, India, looks at how different patch shapes and materials affect The behavior of microstrip patch antennas (MSAs). The study focuses on four types of patch shapes and substrates, considering factors like gain, directivity, bandwidth, and return loss. The researchers used ADS simulation software to simulate and compare the antenna performance for each configuration. The findings provide useful information on how the choice of patch shape and substrate material can impact MSA performance, which can help improve antenna design for different uses.

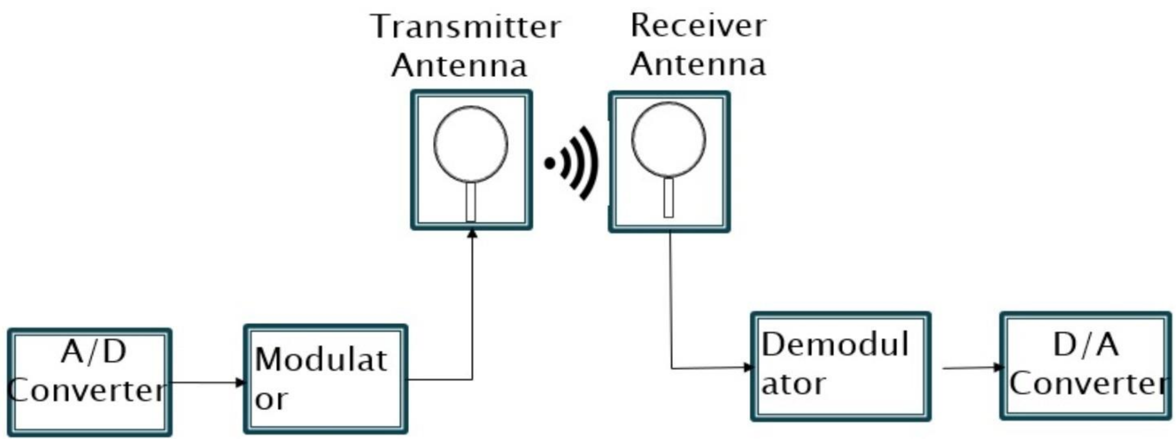
## III. PROBLEM IDENTIFICATION

The design of circular-shaped microstrip patch antennas for C-band applications faces challenges related to narrow bandwidth, limited gain, and low return loss. Existing studies on microstrip antennas have focused on various shapes and substrates, but comprehensive analysis specific to the C-band is lacking. The effect of different substrate materials and dielectric constants on functionality of antenna is not fully explored for C-band frequencies. Therefore, there is A requirement to design a CMPA (circular microstrip patch antenna) with efficient operation in the C-band. This study aims to optimize antenna performance by addressing these limitations and improving bandwidth and overall efficiency.

## IV. PROPOSED METHOD

**Design and analyze** a **circular-shaped microstrip patch antenna** for **5G sub-6 GHz applications** (**C-band**, around **3.5–4.2 GHz**), aiming to achieve **compact size**, **high gain**, and **wide bandwidth**. The antenna will be optimized using techniques such as **slot loading** or **partial ground plane** to enhance **radiation efficiency** and **bandwidth**, making it suitable for integration in **5G mobile** and **IoT devices**.

## V. BLOCK DIAGRAM



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## VI. CONCLUSION

This research analysis of the development and evaluation of CMPA (circular microstrip patch antenna) for C-band applications, addressing the primary challenge of narrow bandwidth that limits their performance in wide-frequency applications like radar systems and communication networks. By analyzing the impact of various substrate materials and dielectric constants on the antenna's key parameters, such as gain, bandwidth, Impedance mismatch loss, and directivity, The study sheds light on methods to optimize antenna performance. Using advanced simulation tools like ADS software, the research demonstrates that with careful design adjustments and optimization, Bandwidth and efficiency can be enhanced of CMPA(circular microstrip patch antennas) functioning at C- band frequencies. This work helps in progress of antenna designs for communication systems, radar technologies, and 5G applications, offering solutions to enhance performance while maintaining low profile, compactness, and cost-effectiveness.

## REFERENCES

[1] S. Pandey and K.Markam, "Design and Analysis of CMPA (circular shape microstrip patch antenna) for C-band Applications," International Journal of Innovative Science, Engineering & Technology, vol. 2, no. 10, pp. 46–50, Oct. 2015.

[2] N. M. Thaker and V. Ramamoorthy, "A Review on CMPA (circular microstrip patch antenna) with Slots for C Band Applications," Wireless Personal Communications, vol. 127, pp. 1–17, 2022..

[3] D. Mittal, A. Nag, and E. Sidhu, "Design and Performance Analysis of MPA (microstrip patch antenna) for C Band Applications," International Journal of Engineering Trends and Technology (IJETT), vol. 48, no. 4, pp. 243–247, June 2017.

[4] J. S. Varma, P. S. Deepika, P. S. Sreeja, V. S. S. Chandra Sekhar, and T. H. S. Reddy, "Design and Analysis of Circularly Polarized MPA (Microstrip Patch Antenna) with Enhanced Bandwidth for C-Band Frequencies," Journal of Science and Technology Development, vol. 13, no. 4, pp. 28–32, Apr. 2024.

[5] C. Mukta, M. Rahman, and A. Z. M. T. Islam, "Design of a Compact CMPA (circular microstrip patch antenna) for WLAN Applications," International Journal of Advanced Networking and Applications, vol. 11, no. 3, pp. 1–5, 2019.

[6] A. Manimegalai and I. Kalphana, "Design and Simulation of Rectangular MPA (microstrip patch antenna) for Satellite Communication at 4.3 GHz," International Journal of Creative Research Thoughts (IJCRT), vol. 8, no. 3, pp. 607–610, Mar. 2020.

[7] M. M. Rahman, M. R. Islam, M. G. S. Uddin, and M. M. Islam, "Design of a Circular Bridged MPA (microstrip patch antenna) for Wireless Communication Systems," International Journal of Electronics and Communications (AEÜ), vol. 131, pp. 1–7, 2021.

[8] A. A. Khan, Z. Wang, D. Li, and A. Ahmed, "A Compact C-Band Multiple-Input Multiple-Output CMPA (circular microstrip patch antenna) Array with Octagonal Slotted Ground Plane and Neutralization Line for Improved Port Isolation in 5G Handheld Devices," Electronics, vol. 13, no. 11, pp. 2196, 2024.

[9] V. H. R. Keerthi, H. Khan, and P. Srinivasulu, "Design of C-Band MPA(microstrip patch antenna) for Radar Applications," IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), vol. 5, no. 3, pp. 49–58, 2013.

[10] M. Meena and P. Kannan, "Analysis of MPA (microstrip patch antenna) for Four Different Shapes and Substrates," ICTACT Journal on Microelectronics, vol. 4, no. 1, pp. 519–530, Jan. 2018.

[11] N. S. Raghava, "Design and Analysis of CMPA (circular microstrip patch antenna) for White Space TV Band Application," International Journal of Electronics and Communications (AEÜ), vol. 131, pp. 1–7, 2022.