



# Compact Triband Antenna for GPS, ISM and WiMAX Applications

Dr.S.C.Sivaprakash, Muthu Yokesh K, Rajeshkanna S, Prasanth B

K.L.N. College of Engineering, Pottapalayam, Sivagangai, India

**Publication History:** Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03.2026; Published: 28.03.2026.

**ABSTRACT:** This paper presents the design and analysis of a compact triband circular microstrip patch antenna intended for wireless communication applications such as Global Positioning System (GPS), Industrial Scientific and Medical (ISM) band devices, and WiMAX communication systems.

With the rapid development of modern wireless technologies, there is an increasing demand for compact antennas capable of supporting multiple frequency bands within a single structure. The proposed antenna is designed using a circular microstrip patch configuration on an FR4 substrate with a relative permittivity of 4.4.

The antenna is optimized to operate at 1.6 GHz, 2.4 GHz, and 3.8 GHz, which correspond to GPS, ISM band applications including Wi-Fi and Bluetooth, and WiMAX communication systems.

The dimensions of the circular patch are calculated using standard microstrip antenna design equations and further optimized through electromagnetic simulation. Simulation results demonstrate good antenna performance with return loss (S11) below -10 dB at the operating frequencies, indicating proper impedance matching and efficient radiation characteristics.

The proposed antenna provides a simple structure, compact size, and effective triband operation, making it suitable for integration in modern multiband wireless communication devices.

**KEYWORDS:** Circular patch antenna, triband antenna, GPS, ISM band, WiMAX, FR4 substrate.

## I. INTRODUCTION

In recent years, the rapid growth of wireless communication systems has created a strong demand for compact and efficient antennas capable of operating at multiple frequency bands. Applications such as Global Positioning System (GPS), Industrial Scientific and Medical (ISM) band devices, and Worldwide Interoperability for Microwave Access (WiMAX) require antennas that support reliable communication while maintaining compact size and low cost.

Microstrip patch antennas have become one of the most preferred antenna types due to their advantages such as low profile, light weight, ease of fabrication, and compatibility with integrated circuits. However, conventional microstrip antennas typically operate at a single frequency band, which limits their application in modern multi-band communication systems.

To overcome this limitation, multiband antennas are designed to operate at multiple frequencies within a single compact structure. Triband antennas, in particular, are widely used in wireless applications as they can support multiple services simultaneously without increasing the antenna size.

In this work, a compact triband microstrip patch antenna is designed to operate at GPS (1.6 GHz), ISM (2.4 GHz), and WiMAX (3.8 GHz) frequency bands. The antenna is designed using an FR4 substrate and optimized to achieve good return loss and efficient radiation performance. The proposed design offers a simple, cost-effective, and compact solution for modern wireless communication systems.



## II. LITERATURE REVIEW

Several research works have been carried out in the field of multiband antenna design to support modern wireless communication systems. Different techniques such as slot loading, defected ground structures, and patch modifications have been used to achieve multiband operation.

In previous studies, microstrip patch antennas have been modified using slots and stubs to obtain dual-band and tri-band characteristics. Some designs focus on improving bandwidth, while others aim to reduce antenna size. However, achieving a balance between compact size, multiple frequency operation, and good radiation characteristics remains a major challenge.

Researchers have also explored the use of different substrate materials and geometries to enhance antenna performance. FR4 substrate is widely used due to its low cost and availability, although it may introduce higher losses compared to other materials.

Therefore, designing a compact triband antenna with good return loss, stable radiation pattern, and acceptable gain remains a challenging task. The proposed work addresses these challenges by developing a simple and compact antenna structure capable of operating efficiently at GPS, ISM, and WiMAX frequency bands.

The proposed antenna design focuses on achieving triband operation with a simple structure, compact size, and acceptable performance, making it suitable for practical applications.

## III. RESEARCH METHODOLOGY

The proposed antenna is designed using a circular microstrip patch structure on an FR4 substrate with a dielectric constant of 4.4. The design process involves selecting appropriate dimensions for the patch, substrate, and ground plane to achieve the desired resonant frequencies. Careful consideration is given to parameters such as patch radius, substrate thickness, and feed position to ensure compact size and efficient performance.

Simulation of the antenna is carried out using electromagnetic simulation software to analyze its performance characteristics in detail. The parameters such as return loss (S11), Voltage Standing Wave Ratio (VSWR), and radiation pattern are evaluated to ensure proper antenna operation. These parameters help in determining the efficiency of power transmission and the overall effectiveness of the antenna design.

The antenna is designed to resonate at three frequency bands: 1.6 GHz, 2.4 GHz, and 3.8 GHz. Optimization techniques are applied to achieve good impedance matching and efficient radiation at all frequencies. Minor adjustments in the geometry and feed structure are performed to fine-tune the resonant frequencies and improve overall antenna performance.

After simulation, the antenna is fabricated on an FR4 substrate using standard PCB fabrication techniques. The fabricated antenna is then tested and analyzed to validate the simulation results. The measured results are compared with the simulated values to ensure consistency and reliability of the proposed design.

Additionally, the overall design approach focuses on achieving a balance between compact size, cost-effectiveness, and multiband performance, making the antenna suitable for practical wireless communication applications.

## IV. RESULTS AND DISCUSSION

The performance of the proposed triband antenna is evaluated through both simulation and practical measurements. The antenna is analyzed based on key performance parameters such as return loss (S11), VSWR, and radiation characteristics. The objective is to ensure that the antenna operates efficiently at the desired frequency bands of 1.6 GHz, 2.4 GHz, and 3.8 GHz with good impedance matching and stable radiation performance.

The simulated return loss (S11) characteristics of the antenna indicate that it resonates effectively at the three target frequencies. The S11 values are observed to be below  $-10$  dB at all operating bands, which confirms good impedance matching and minimal signal reflection. This ensures that maximum power is transmitted from the feed to the antenna, thereby improving overall efficiency.

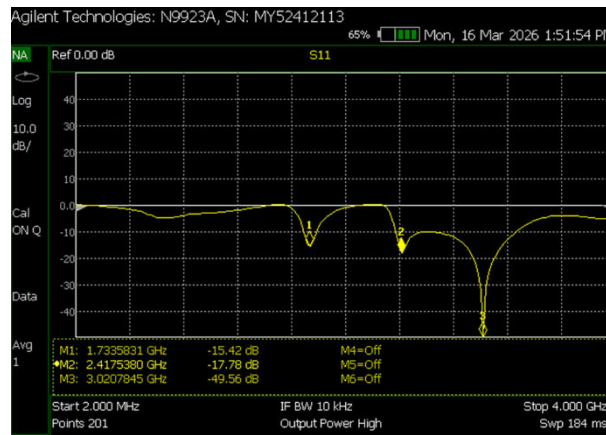


FIG 1. Return Loss

The Voltage Standing Wave Ratio (VSWR) of the antenna is also evaluated to verify the impedance matching performance. The VSWR values are found to be less than 2 at all operating frequencies, which indicates acceptable matching conditions. This confirms that the antenna is capable of efficient power transmission with minimal losses across all three frequency bands.

The designed antenna is fabricated on an FR4 substrate using standard PCB fabrication techniques. The fabricated prototype is tested under practical conditions to validate the simulation results. The physical structure of the antenna is compact and easy to implement, making it suitable for real-world wireless communication applications.

The radiation pattern of the antenna is analyzed to study its directional characteristics. The antenna exhibits stable and nearly omnidirectional radiation patterns, which are suitable for applications such as GPS, ISM, and WiMAX. The gain and efficiency of the antenna are also found to be within acceptable limits, ensuring reliable communication performance.

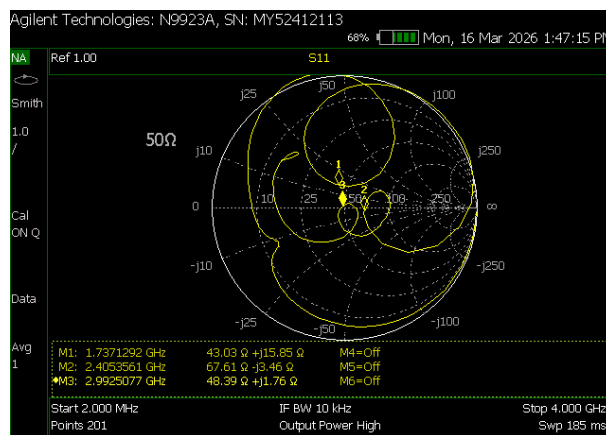


FIG 2: Radiation Pattern

The fabricated antenna demonstrates performance characteristics that are in close agreement with the simulated results, with only minor variations due to fabrication tolerances and material losses. Overall, the results confirm that the proposed antenna successfully achieves triband operation with good return loss, acceptable VSWR, and stable radiation characteristics, making it suitable for modern wireless communication systems.



FIG 3: Fabricated Antenna

## V. CONCLUSION

The design and development of a compact triband microstrip patch antenna for GPS, ISM, and WiMAX applications have been successfully presented in this work. The proposed antenna operates at three distinct frequency bands of 1.6 GHz, 2.4 GHz, and 3.8 GHz, making it suitable for multiple wireless communication systems. The use of a simple circular patch structure ensures compactness and ease of implementation. The antenna is designed using an FR4 substrate, which offers a cost-effective and widely available solution for practical applications. The simulation results demonstrate that the antenna achieves good impedance matching with return loss values below  $-10$  dB at all operating frequencies. The VSWR values are also within acceptable limits, indicating efficient power transmission. The fabricated antenna prototype is tested and analyzed, and the measured results using VNA show good agreement with the simulated values. Minor variations are observed due to fabrication tolerances and material losses, which are expected in practical implementations. The antenna exhibits stable radiation characteristics, making it suitable for real-world applications. Overall, the proposed antenna provides a compact, low-cost, and efficient solution for multiband wireless communication systems. The design can be further enhanced by improving parameters such as bandwidth and gain, making it more suitable for advanced and high-performance communication applications.

## VI. FUTURE WORK

The proposed antenna design can be further improved and extended in several ways to enhance its performance and applicability in advanced wireless communication systems. The following future enhancements can be considered:

1. The bandwidth of the antenna can be improved by using advanced techniques such as defected ground structures (DGS) or slot modifications.
2. The gain of the antenna can be increased by incorporating array configurations or using parasitic elements.
3. The antenna size can be further reduced using miniaturization techniques such as fractal geometries or metamaterials.
4. The performance of the antenna can be enhanced by replacing the FR4 substrate with low-loss materials such as Rogers RT/duroid.
5. The antenna can be optimized to support additional frequency bands for emerging wireless technologies.
6. Integration of the antenna with real-time communication systems can be carried out to validate its practical performance.
7. Advanced simulation and optimization algorithms can be applied to further improve efficiency and radiation characteristics.
8. The antenna can be tested under different environmental conditions to evaluate its robustness and reliability in real-world applications.



## REFERENCES

1. D. M. Pozar and D. H. Schaubert, *Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays*. New York, NY, USA: IEEE Press, 1995.
2. K. L. Wong, "Planar antennas for wireless communications," *IEEE Transactions on Antennas and Propagation*, vol. 46, no. 6, pp. 866–873, Jun.1998
3. H. Wong, K. M. Luk, and C. H. Chan, "Small antennas in wireless communications," *Proceedings of the IEEE*, vol. 100, no. 7, pp. 2109–2121, Jul. 2012.
4. D. M. Pozar and D. H. Schaubert, "Microstrip antennas: The analysis and design of microstrip antennas and arrays," *IEEE Transactions on Antennas and Propagation*, vol. 36, no. 8, pp. 1012–1024, Aug. 1988.
5. K. L. Wong, *Compact and Broadband Microstrip Antennas*. New York, NY, USA: John Wiley & Sons, 2002.
6. C. A. Balanis, "Modern antenna handbook," *IEEE Press Series on Electromagnetic Wave Theory*, 2008.
7. G. Kumar and K. P. Ray, *Broadband Microstrip Antennas*. Norwood, MA, USA: Artech House, 2003.
8. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor & Francis, *Electric Power Components and Systems*, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
9. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - *Journal of Electrical Engineering*, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
10. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, *Electrical Engineering*, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
11. S.Tamilselvi, R.Prakash, C.Nagarajan, "Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" *Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering*, DOI10.1007/s40998-025-00917-z,2025
12. S.Tamilselvi, R.Prakash, C.Nagarajan, " Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" *Electric Power Systems Research* 253 (2026) 112428, doi.org/10.1016/j.epsr.2025.112428
13. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," *Journal of Electrical Engineering And Technology*, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
14. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- *Acta Electrotechnica et Informatica Journal* , Vol.13 (2), pp.18-31, April-June.2013, DOI: 10.2478/aeeci-2013-0025.
15. C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- *Springer, Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.
16. C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.
17. C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai. Vol.no.1, pp.190-195, Dec.2007
18. Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", *Revista Materia (Rio J.)* Vol. 30, 2025, DOI: <https://doi.org/10.1590/1517-7076-RMAT-2024-0721>
19. M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", *Journal of Environmental Protection and Ecology*, Volume 23, Issue 2, pp: 520-530,2022
20. M. Ali, M. Okoniewski, and M. A. Stuchly, "Dual-frequency strip-sleeve monopole antenna for laptop computers," *IEEE Transactions on Antennas and Propagation*, vol. 47, no. 2, pp. 317–323, Feb.1999.
21. Vimal, V. R., & Banerjee, J. S. (2025). Integrating PSO, GA, and ACO for Optimized ECG Feature Selection and Classification of Cardiac Disorders. *SGS-Engineering & Sciences*, 1(5).
22. Gopinathan, V. R. (2025). AI-Powered Kubernetes Orchestration for Complex Cloud-Native Workloads. *International Journal of Research Publications in Engineering, Technology and Management (IJRPETM)*, 8(6), 13215-13225.