ESP IJAST
ESP International Journal of Advancements in Science & Technology
ISSN: 2583-9233 / Volume 2 Issue 2 May 2024 / Page No: 22-26
Paper Id: IJAST-V2I2P105 / Doi: 10.56472/25839233/IJAST-V2I2P105

*Original Article*

# An Overview of Antennas for Wireless Sensor Networks and Possible Future Prospects

**Elamaran P[1], Dr. Kavitha M.G[2]**
[1]*Government Polytechnic College, Gandharvakottai, Tamilnadu, India.*
[2]*University College of Engineering, Pattukkottai, Tamilnadu, India.*

Received Date: 11 March 2024 Revised Date: 08 April 2024 Accepted Date: 10 May 2024

***Abstract:*** *Antennas have become increasingly vital across various domains, driven by advancements and a plethora of benefits they offer. Reconfigurable antennas, in particular, have found extensive application in personal healthcare, entertainment, military, and beyond. Their adaptability allows for superior performance compared to fixed antennas, as they can adjust parameters according to requirements.*

*In the realm of modern wireless applications, there's a growing need for antennas with integrated capabilities and functionalities. These include agility in resonant frequency spectrum, polarization, and radiation pattern diversity within a single device. Reconfigurable antennas emerge as a solution to meet such demands effectively. They offer versatility, allowing adjustments in frequency, pattern, or polarization, thus catering to diverse requirements.*

*In secure communications, antennas with reconfigurable radiation patterns are highly sought after. They play a crucial role in preventing signal information leakage, enhancing security measures. This paper aims to present an overview of existing antennas and their applications, with a focus on addressing limitations associated with wearable antennas. By understanding these aspects, it becomes possible to envision potential advancements in the field, paving the way for future innovations.*

***Keywords:*** *Reconfigurable Antenna, Frequency Spectrum, Polarization, Radiation Pattern.*

## I. INTRODUCTION

### A. Planar Yagi-Uda Antenna with Pattern Reconfiguration

Wireless sensor networks (WSNs) comprise small, energy-efficient devices designed to monitor various physical or environmental conditions. These networks find applications across diverse domains such as healthcare, industry, environmental monitoring, and structural health monitoring. Typically, WSN nodes are equipped with omnidirectional antennas like monopoles or dipoles. However, these antennas utilize only a fraction of the radiated power effectively, while the rest is wasted. Introducing switched beam antennas to WSN nodes allows for the reconfiguration of antenna radiation patterns, directing the beam towards specific nodes, thereby optimizing power usage.

Directional antennas offer significant advantages over omnidirectional ones in WSN environments, improving energy consumption, receiver sensitivity, and propagation range. Despite their potential benefits, the integration of directive antennas into WSN nodes remains relatively unexplored. Some existing works have proposed reconfigurable antennas for WSN sink nodes capable of switching between conical and front-directional patterns. However, these antennas are often large in size and lack radiating beams in the azimuth direction, limiting their practicality for WSN integration.

Recent research endeavors have concentrated on pattern adaptable antennas rooted in the Yagi-Uda principle. An example of such a design entails a parasitic flat patch antenna adept at multifaceted pattern reconfiguration. This antenna arrangement consists of a driven component encircled by four parasitic elements serving as reflectors or directors, contingent upon the switching configuration. Beam adjustment is facilitated via the utilization of PIN diode switches. Another breakthrough entails an amplified planar Yagi-Uda antenna with pattern adaptability, showcasing prospective strides in Wireless Sensor Network (WSN) antenna technology.

This paper introduces a Frequency Reconfigurable microstrip patch antenna with a Yagi-Uda shape design. Featuring four patches, this antenna is tailored to cover the frequency band spanning from 1.9GHz to 2.4GHz. Its standout feature lies in its ability to alter frequency, consequently modifying return loss characteristics based on configuration requirements. This frequency reconfiguration capability is enabled by PIN diodes, functioning as switches to adjust the antenna. Rectangular patches serve as switches to facilitate re-configurability.

Simulated results demonstrate a return loss lower than –dB and a VSWR below 2.5, indicating excellent performance. The versatility of the proposed antenna extends to compatibility with various wireless standards including Bluetooth, Wi-Fi, WLAN, 3G, UMTS, WCDMA, GSM, and CDMA. Leveraging three PIN diodes, frequency switching between different standards becomes feasible. Notably, the proposed antenna boasts a straightforward fabrication process owing to its planar structure, compact size, and desirable radiation characteristics such as return loss and VSWR.

**B. Planar Printed Rectangular Monopole Antenna**

This paper presents the design of a compact, ultra-wideband electronically switchable dual-band microstrip planar printed rectangular monopole antenna (PRMA), capable of transitioning from omnidirectional to directional radiation patterns. With dimensions optimized to 0.26 λo × 0.28 λo, the antenna system integrates radiators, reflectors, and symmetrical grounds on a single layer.

Frequency agility and radiation pattern control are achieved through the use of two SMD PIN diodes. At the C-band frequency spectrum, the antenna produces directional radiation patterns with 180° phase shiftsIn phase one, emission occurs at 7.2 GHz (6.345-7.567 GHz) in the angle of 270°, resulting in a gain of 2.1 dBi. Transitioning to phase two, radiation shifts to 6.826 GHz (4.5 –7.9 GHz) in the angle of 90°, maintaining the same gain. Phase three exhibits X-band frequency emission centered at 9.93 GHz (8.845–10.49 GHz), presenting an all-directional pattern with a gain of 4.1 dBi. Because of these characteristics, the suggested antenna is a good fit for high-speed wireless sensor network connection in sectors like pharmaceuticals and oil and gas chemical reactors.

**C. Multi-Directional Switched Beam Antenna**

This paper presents a multi-directional switched beam antenna designed for operation at 2.45 GHz, specifically customized for wireless sensor network (WSN) usage. The antenna's beam can be flexibly oriented towards the central axis within a range of ± 80° in both horizontal and vertical planes. By stimulating the two ports with a phase difference of 90°, the antenna attains circular polarization when the beam is aligned with the central axis.

Importantly, the antenna maintains resonance frequency within a 2:1 Voltage Standing Wave Ratio (VSWR) bandwidth regardless of the direction of the switched beam. This ensures consistent performance across different beam configurations. The directive gain of the antenna surpasses that of a dipole antenna at various tilt angles, rendering it highly suitable for WSN applications. Additionally, the presence of two ports provides flexibility in selecting the desired polarization.

To further enhance radiation efficiency, employing low-loss dielectric substrate materials is recommended. Additionally, ongoing research focuses on integrating PIN diodes as switches along with the bias network to enable more advanced functionality and performance optimization. Overall, the proposed antenna offers significant potential for enhancing WSN communication capabilities through its multi-directional beam switching capability, polarization flexibility, and potential for radiation efficiency improvements.

**D. A Pattern-Reconfigurable Yagi–Uda Antenna Based On Liquid Metal**

In this article, a Yagi-Uda antenna with adaptable patterns is presented, utilizing liquid metal technology. The antenna setup includes an active dipole fed by a balun, alongside two flexible passive parasitic dipoles fashioned from eutectic gallium-indium (EGaIn) alloy within microfluidic channels. Manipulation of these parasitic dipoles is achieved using inexpensive three-dimensional printed rods, which, when rotated at different angles, cause varying levels of elongation in the dipole components.

Most importantly, antenna radiation reconfiguration is highly dependent on the length of the passive parasitic dipoles. Bidirectional radiation is displayed by the antenna when the lengths of these dipoles are equal. On the other hand, by modifying the dipole lengths appropriately, directed radiation towards the shorter parasitic dipole direction can be accomplished. This idea is used to manufacture and measure a pattern-reconfigurable antenna that operates in the 2.4–2.48 GHz wireless local area network (WLAN) spectrum.

This design simplifies the manufacturing process by fabricating the microfluidic channels without requiring a furnace, in contrast to other methods. Additionally, to guarantee the integrity of the antenna components, connections are made using both chemical (gluing) and physical (welding) methods. By adjusting the angle of the rotating rods, the antenna transitions between bidirectional and directional radiation states.

**E. Polarization Reconfigurable Printed Monopole Antenna**

This paper proposes a simple polarization reconfigurable printed monopole antenna designed for wireless applications. Utilizing conducting strips connected to the ground plane, the antenna introduces additional modes essential for circular polarization. Through the integration of only two PIN diodes, which connect to the ground plane, the antenna achieves linear polarization, right-hand circular polarization (RHCP), or left-hand circular polarization (LHCP) without significantly impacting radiation characteristics.

Key antenna characteristics are carefully examined and optimized, and the operational mechanism is clarified. After prototyping, extensive testing is carried out to assess every possible configuration of polarization. Interestingly, the diodes are placed in a deliberate manner in relation to the ground plane so as to reduce their impact on radiation properties. Experimental results reveal an axial ratio (AR) bandwidth of 4.5% and 4.4% for RHCP and LHCP configurations, respectively. Additionally, the measured realized gain stands at 1.2 dBic for RHCP, 0.6 dBic for LHCP, and 0.5 dBi for linear polarization configurations at 2.4 GHz.

**F. A Reconfigurable Antenna with Radiation Pattern and Polarization Reconfiguration**

This article investigates a versatile antenna capable of adjusting both its radiation pattern and polarization. The antenna design consists of a core dielectric resonator antenna (DRA) and two additional parasitic DRAs formed from a liquid solution known for its minimal dielectric loss. By controlling the liquid flow, the arrangement of the parasitic DRAs can be modified to produce various radiation patterns. Specifically, the antenna can achieve an omnidirectional pattern when only the central DRA is active, while activating the parasitic DRAs enables the attainment of a unidirectional pattern. Moreover, by varying the configuration of the parasitic DRAs via liquid flow, the antenna's polarization can be modified, allowing for the realization of different polarization states.

Leveraging this principle, the antenna offers three distinct radiation states: omnidirectional radiation and unidirectional radiation with either x- or y-polarization. To validate the design, a prototype operating at 2.4 GHz was simulated, fabricated, and subjected to measurement. Results indicate effective impedance matching across the operating band, alongside the anticipated radiation pattern and polarization reconfiguration capabilities.

**G. A Reconfigurable Antenna Design Consideration**

This paper investigates radio frequency microelectromechanical system (RF MEMS) switch applications in the design of flexible antennas. Practical aspects of using these switches, like changing antenna feeding networks or topologies, are the main focus of the design parameters. The first design approach uses a coplanar waveguide (CPW)-to-microstripline transition technique to seamlessly integrate tiny switches into the antenna feeding networks, allowing beam steering. The other method involves using switches to alter the antenna ground plane configuration in order to enable frequency switching. Both antenna configurations are fully simulated using a Finite-Difference Time-Domain (FDTD) simulator. The frequency switching antenna is expected to achieve scanning angles larger than sixty degrees, and the beam steering antenna.

**H. A Reconfigurable Meta Material Antenna**

This paper introduces a novel concept: reconfigurable metamaterials. These materials hold significant promise across various applications where adaptivity, flexibility, multifunctionality, and miniaturization are essential or beneficial.

**I. A Reliable Data Collection Mechanism (RDCM) Which Uses Six Directional Antennas**

Wireless Sensor Networks (WSNs) are essential for improving operational efficiency in smart industrial applications. Nonetheless, node localization in interior contexts continues to be a major difficulty. Directed antennas are suggested as a viable method in WSNs to reduce interference and collisions in order to overcome this constraint. In order to produce a comprehensive radiation pattern, this work presents a novel Reliable Data Collection Mechanism (RDCM) that makes use of six directional antennas. The flexibility of this transceiver module allows it to function in both directed and all-encompassing radiation pattern modes, which facilitates accurate data collecting and node localization. The suggested method uses a Local Sink (LS) strategy to gather data, choosing the LS based on node energy, velocity, and connection duration. The Base Station receives data collected by the LS. (BS)

Furthermore, the proposed mechanism incorporates Distributed Mobility Control (DMC) for efficient node localization, resulting in uniform energy consumption and improved link accessibility. The use of directional antennas simplifies the deployment of devices by eliminating the need for manual coordinate calculations, offering high precision and real-time data analysis capabilities. As a result, the RDCM presents an efficient solution for industrial automation, particularly in scenarios such as chemical plants where it can accurately detect the exact position of poisonous gas leakage in unattended areas.

**J. A Dual-Band Microstrip Patch Antenna Using a Capacitor-Loaded Slot**

The communication introduces a new method for creating a dual-band microstrip patch antenna using a capacitor-loaded slot. This antenna has inductive and capacitive characteristics at lower frequencies, allowing for electronically reconfigurable operation. The antenna achieves a gain of 7 dBi at the lower frequency band and 38% to 90% at the higher frequency band. The proposed antenna is suitable for base stations and terminals in wireless networks, including cognitive and software-defined radio systems.

**K. A Frequency and Pattern Reconfigurable Rectangular Microstrip Patch Antenna Using a Single Switch**

This paper introduces the design of a frequency and pattern reconfigurable rectangular microstrip patch antenna employing a single switch. The antenna operates in two modes contingent on the state of the switch, exhibiting reconfigurability in frequency and radiation pattern at frequencies of 2.47 GHz, 3.8 GHz, and 5.36 GHz. Utilizing only one PIN diode as a switch, this design strategically places biasing lines and elements away from the radiating structure.

The objective is to mitigate distortions commonly observed in the radiation characteristics of reconfigurable antennas when multiple switches and complex biasing circuitry are employed. Although the proposed antenna's dimensions are relatively large, further research is warranted to reduce its size while maintaining frequency and pattern reconfigurability. The aim is to minimize additional circuitry to streamline complexity in future iterations.

**L. The Design and Measurement of an Antenna Integrated into a Sensor Network**

The paper presents a Bowtie-Shaped Folded Dipole (BSFD) antenna designed for agricultural sensor network nodes, operating on the 2.4 GHz ISM band using ZigBee protocol stack. The antenna matches a controller's differential 100Ω input impedance, outperforming two previous WSN antennas. The design is tested using conventional single-ended equipment and radiation pattern measurements, demonstrating a maximum received power increase of over 4 dB.

During field trials, the prototype equipped with the Bowtie-Shaped Folded Dipole (BSFD) achieves an impressive coverage of nearly 300 meters, tripling the standard range for ZigBee applications. The paper also introduces a novel printed differential dipole antenna, the BSFD, and verifies its performance using diverse methodologies. Employing printed baluns yields precise outcomes for differential impedance measurements, demonstrating superiority over other prevalent techniques utilizing coaxial test-fixtures.

The communication presents a novel approach to use a capacitor-loaded slot to create a dual-band microstrip patch antenna. At lower frequencies, this antenna exhibits both inductive and capacitive properties, enabling electronically reconfigurable operation. In the lower frequency band, the antenna achieves a gain of 7 dBi, and in the higher frequency band, it achieves a gain of 38% to 90%. The suggested antenna works well with software-defined radio systems and cognitive base stations and terminals in wireless networks.

Furthermore, the BSFD antenna substantially amplifies the received power by the node in comparison to conventional off-the-shelf solutions, thereby extending the typical reach of Wireless Sensor Network (WSN) applications for the same power output. The fully operational prototype featuring the BSFD antenna is manufactured using widely available fabrication technology, resulting in decreased system costs and power demands.

**Table 1: Overview of Different Types of Antenna**

| Type of antenna | Frequency | Applications | Limitation |
|---|---|---|---|
| Planar Yagi-Uda antenna | 1.9GHz to 2.4GHz | Wi-Fi, WLAN, 3G, UMTS, WCDMA, GSM, CDMA | Low radiation efficiency |
| Multi-directional switched beam antenna | 2.4 GHz | WLAN | Cross polarization |
| A pattern-reconfigurable Yagi–Uda antenna based on liquid metal | 2.4–2.48 GHz | WLAN | Low Radiation efficiency, low gain |
| A Reliable Data Collection Mechanism (RDCM) which uses six directional antennas | -- | Wireless Sensor Networks | Cross polarization is high |
| Frequency and pattern reconfigurable rectangular microstrip patch antenna using a single switch | 2.47 GHz, 3.8 GHz and 5.36 GHz | Wireless applications | Low radiation Efficiency |
| A dual-band microstrip patch antenna using a capacitor-loaded slot | 2.22 to 2.26 GHz 3.24 to 4.35 GHz | Wireless networks, including cognitive and software defined radio systems. | Cross polarization is high |
| The design and measurement of an antenna integrated into an sensor network | 2.4 GHz | Wireless Sensor Networks | Low gain |

## II. CONCLUSION

This review explores various methods for implementing antennas in wireless sensor networks (WSNs), presenting results from different antenna types to elucidate their implementation. Designing antennas for WSNs is a critical task, necessitating careful consideration of factors studied in the aforementioned antennas to achieve cost-efficiency, lightweight, and compact designs for communication purposes.

Expanding antenna technology into healthcare holds promise for enhancing healthcare experiences in the future, particularly in precision medicine and treatments. The ability to provide healthcare support in underprivileged or remote regions stands to greatly benefit from more feasible and cost-effective technologies. Consequently, numerous avenues within antenna research remain to be explored, offering substantial potential for future studies to address and advance this field.

## III. REFERENCES


[1] Sowmyadevi A, Phalguni Mathur, Anupam R Chandran, Nick Timmons, Jim Morrison and Sujith Raman "2.45 GHz Pattern Reconfigurable Antenna for Wireless Sensor Network applications" URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

[2] Jiaxiang Hao, Jian Ren , Xiaoyu Du , Jan Hvolgaard Mikkelsen , Ming Shen ,and Ying Zeng Yin "Pattern-Reconfigurable Yagi–Uda Antenna Based on Liquid Metal"IEEE Antennas And Wireless Propagation Letters, Vol. 20, No. 4, April 2021

[3] Kushal Walia, 2024. *"Accelerating AI and Machine Learning in the Cloud: The Role of Semiconductor Technologies" ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 2: 34-41.

[4] Panahi, X. L. Bao, K. Yang, O. O'Conchubhair and M. J. Ammann"A Simple Polarization Reconfigurable Printed Monopole Antenna" IEEE Transactions on Antennas and Propagation

[5] Jian Ren, Zhao Zhou, Zhao Hui Wei, Hao Ming Ren, Zhe Chen, Ying Liu and Ying Zeng Yin"Radiation Pattern and Polarization Reconfigurable Antenna Using Dielectric Liquid" IEEE Transactions on Antennas and Propagation

[6] Thermpon Ativanichayaphong, Ying Cai, Jianqun Wang, Mu Chiao* and J.-C. Chiao "Design Considerations of Reconfigurable Antennas using MEMS Switches" Proc. of SPIE Vol. 6035 60351Y-1 to 8.

[7] Giacomo Oliveri, Douglas H. Werner and Andrea Massa "Reconfigurable Electromagnetics Through Metamaterials-AReview" IEEE Proceedings of the IEEE

[8] Kalaivanan Karunanithy a,∗, Bhanumathi Velusamy b"Directional antenna based node localization and reliable data collection mechanism using local sink for wireless sensor networks" Journal of Industrial Information Integration 24 (2021) 100222

[9] Kushal Walia, "Exploring the Challenges of Serverless Computing in Training Large Language Models," International Journal of Computer Trends and Technology, vol. 72, no. 4, pp. 71-76, 2024. Crossref, https://doi.org/10.14445/22312803/IJCTT-V72I4P109

[10] Ahmed Khidre, Fan Yang, and Atef Z. Elsherbeni "A Patch Antenna With a Varactor-Loaded Slot for Reconfigurable Dual-Band Operation"IEEE Transactions On Antennas And Propagation, Vol. 63, No. 2, February 2015

[11] Anuradha A. Palsokar, S.L. Lahudkar "Frequency and pattern reconfigurable rectangular patch antenna using single PIN diode"Int. J. Electron. Commun. (AEÜ) 125 (2020) 153370

[12] Sridhar Selvaraj, 2024. *"Futuristic SAP Fiori Dominance" ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 1: 32-37.

[13] Nuno Pires, Tiago Parra, Anja K. Skrivervik, and Ant´onio A. Moreira "Design and Measurement of a Differential Printed Antenna for a Wireless Sensor Network Node" IEEE Antennas And Wireless Propagation Letters, Vol. X, 2017

[14] Kushal Walia, 2024. *"Scalable AI Models through Cloud Infrastructure" ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 2: 1-7.

[15] Jabin Geevarghese George (2024). Leveraging Enterprise Agile and Platform Modernization in the Fintech AI Revolution: A Path to Harmonized Data and Infrastructure, *International Research Journal of Modernization in Engineering Technology and Science, Volume 6, Issue 4: 88-94*

[16] Sridhar Selvaraj, 2024. *"SAP Supply Chain with Industry 4.0" ESP International Journal of Advancements in Computational Technology (ESP-IJACT)* Volume 2, Issue 1: 44-48.