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Literature survey paper on triangle shaped patch antenna

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Abstract: The rapid growth of wireless communication technologies has made it necessary to improve antenna systems to meet demands for compactness, flexibility, and multifunctional. Among various antenna types, micro strip patch antennas (MPAs) have become a dominant and versatile choice for wireless applications. This literature survey focuses on recent developments in the design and analysis of MPAs, particularly for use in wireless communication systems. It reviews different design techniques, as well as analytical and numerical methods, and highlights emerging applications and challenges in the field. By summarizing the latest research, the survey provides an over view of the current state of MPA technology for wireless applications.

Keywords: Micro strip Patch Antenna, wavelength, Directivity.

I. INTRODUCTION

In modern era, speedy changes in wireless communication system led to a need of an antenna that can nurture services like Wireless Local Area Network (WLAN), UWB (Ultra-Wide Band) and Bluetooth. Multipurpose ultra-wide band antenna has become popular after their adoption by Federal Communication Commission (FCC) in 2002. UWB antennas can replace various integrated antenna elements on the ICs of handheld devices there upon making equipment's versatile and portable. Manufacturing of UWB antennas, offered low cost with high performance rate, low consumption of power, short range of operation and simplest design features. Properties like less weight, low profile, formal design, ease of integration and fabrication has increased the popularity of UWB micros trip of patch antenna. Present day studies on patch antennas are notably shifting to higher frequency band (Kurtz-under (Ku), Kurtz (K) and Kurtz-above (Ka) bands) due to plentiful applications in the field of mobile, radar, communication or broadcast satellite services. According to the norms of international telecommunication union, researchers are resurging in research on designing or optimizing antennas for direct broadcast services (DBS) and fixed satellite services

II. LITERATURE SURVEY

This paper, An efficient wideband micro strip patch antenna is introduced here and partial Ka band applications are proposed. The proposed antenna structure consists of C-slot triangular patch with etched edges. The edges are cut for obtaining wide bandwidth. Simulation of proposed antenna is done through Ansoff's more frequency structure simulator (HFSS version 14.0). The prototype is taken with size (20 x 20 x 1.6) mm that attains constant group delay, wide bandwidth and good radiation patterns for the whole operating bandwidth from 15 GHz to 36 GHz (21 GHz) with 82.35% impedance bandwidth at 25.5 GHz Centre frequency. The evaluated of proposed antenna shows fine conformity with the simulated result. Hence, the introduced antenna is applicable for wireless and satellite communication in UWB (ultra-wide band) range for K and partial Ka bands.

This paper [2] presents the design and development of single and dual-element triangle shaped flex patch antennas for WLAN applications operating at 2.4 GHz. Both antenna structures utilize a proximity feeding technique to enhance performance. The designs are simulated and optimized using HFSS software to achieve the desired operating frequency and efficient radiation characteristics. The simulation process helps determine the optimal dimensions for each antenna configuration. Based on the best simulation results, the antennas are fabricated for real-world testing. The study compares the quantity of w ork of both single dual-element designs, evaluating parameters such as return loss, bandwidth, and radiation pattern. The optimized designs show good agreement between simulated and measured results. This confirms the effectiveness of the design process. The fabricated antennas demonstrate potential for practical WLAN applications. Overall, the paper contributes to the development of compact and efficient of antennas using triangular patch geometry.

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This paper[3] proposes a modification to the conventional printed antenna by changing the ground plane design, resulting in a significantly wider bandwidth of 1.78 GHz. Compared to traditional antennas with full ground planes, this change improves performance, making it suitable for diverse 5G applications that span multiple frequency bands. The modified ground plane affects the current distribution on the antenna, leading to a bidirectional radiation pattern rather than the typical hemispherical pattern. This bidirectional pattern is useful in applications where directing the radiation in a specific direction is necessary. These advancements in antenna design help meet the increasing demands of modern communication systems, particularly in the context of 5G.

Researchers [4] proposed antennas that offer enhanced gain, directivity, and bandwidth, specifically designed for 5G wireless communication systems. The operation results were consistent with those of previous studies, demonstrating that the proposed antennas are effective and suitable for use in 5G applications. This makes them a promising option for addressing the high-performance requirements of modern wireless networks.

Researchers in [5] unveil a u-Patch antenna humming from 3.2 to 3.5GHz. This versatile antenna sets its sights on conquering multiple performance metrics. From communication satellites beaming data across the cosmos to weather radars peering into the sky, this antenna's diverse applications are as impressive as its capabilities. It even stands as a benchmark for fidelity in wireless local area networks. With its comprehensive performance profile, this antenna promises to be a game- changer in the ever-evolving wireless landscape.

In a separate study, they [6] modeled a Flex Patch antenna for prospective integration into future 5G communication technologies. The simulation results indicated remarkable performance metrics, including a return loss of -37.96 dB, gain of 8.198 dB, radiation efficiency of 76.9%, and a side-lobe level of -18.3 db. These findings surpassed previous research endeavors, positioning the antenna as a strong contender for 5G wireless technology.

In [7], researchers designed a compact and efficient Microwave patch antenna (MPA) specifically for 5G applications. The antenna operates at 3.6 GHz, which makes it suitable for the lower 5G frequency bands. Its simple T-shaped design allows easily into small devices. Additionally, a cleverly placed slot in the T- shaped patch helps achieve a less operating frequency while maintaining high radiation efficiency and impressive peak gain. This innovative design offers a promising solution for the antenna requirements in the 5G era.

A 5G-specific micro strip patch antenna design device makes its debut in research by [8]. This antenna, sporting a "slotted octagonal" patch, perfectly aligning with future5G communication needs. Its compact design and aesthetically pleasing radiation pattern make it a visually appealing and technically sound option. The research delves deep into the antenna's geometry, meticulously analyzing its key performance indicators. These indicators are thoroughly examined, showcasing the antenna's capability to deliver reliable 5G connectivity.

In another study, researchers [9] introduced the antenna whose geometry's inductance was optimized within the scope of this work using analytical models. The resulting antenna exhibited a wide operating impedance range in the ‘S’ and ‘C’ bands, demonstrating efficacy in the 5G sub-6 GHz band, as well as compatibility with Bluetooth and Wi-Fi band;

In their study, authors [10] propose development of a circularly polarized printed radiator for satellite communication. The key methodology involves employing a truncated corner square patch to achieve circular polarization, a critical feature for effective satellite communication systems. However, the paper acknowledges limitations, including a limited exploration of the potential impact of environmental factors on circular polarization. Additionally, practical challenges in maintaining the desired polarization characteristics in real-world applications are acknowledged.

They proposed [11] a dual band patch antenna array tailored for wearable electronics. The key methodology involves adopting a stacked patch configuration to achieve dual-band operation. The paper notes that this configuration, while beneficial for wearable applications, introduces increased complexity in fabrication. Additionally, there is a request for additional research on the impact of body proximity on the antenna's radiation patterns, recognizing potential challenges in real-world wearable scenarios.

The use of this feeding technique proves effective in controlling the antenna's impedance, particularly due to its flat structure. Critical parameters such as length, width, patch dimensions, ground characteristics, and feedline specifications must be accurately computed once the substrate material is finalized [12].

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A large bandwidth flex patch antenna are designed with a notched ground structure to mitigate interference was introduced [13]. The methodology involves incorporating a notched ground structure to enhance the antenna's bandwidth and reduce unwanted signals. Despite the success in interference reduction, the paper recognizes limitations such as potential challenges in miniaturization and fabrication complexities associated with intricate ground structures. This projected antenna is functioned in the multi-band frequencies of 2.4GHz,3.65GHz, and 5.45 GHz. This can be achieved by implementing defected ground structure on the bottom arrangement to the patch antenna. So that the antenna perturbed well with the ground system and resonates the expected frequency properly below -10db of return loss. The return loss is minimized with the DGS arrangement and these frequencies can be applicable in WLAN and Wide Band. Herewith achieved miniaturized flex Patch Antenna (MPA) suitable for 2.45 GHz WiMAX/WLAN uses and 2.4/3.65/5.45GHz for Wide Band applications [14].

This paper discusses the increasing practicality of integrating antennas directly onto circuit boards, especially in mobile phones. Microwave patch antennas, which are inexpensive, compact, and easy to manufacture, are becoming more widely used. However, one challenge is that a smaller patch size requires a heavy dielectric constant, which can reduce bandwidth. To improve performance, the antenna size must be increased to enhance both efficiency and bandwidth. The draft of compact antennas is crucial for modern electronic devices. In this study, a hexagon-shaped patch antenna was proposed to achieve better return loss, gain, and directivity, which are essential for high-throughput applications in fields like biomedical systems. The introduced antenna operates at 2.4 GHz with a VSWR of lesser than 2 and achieves a gain of 3 dB[15].

III. PROBLEM IDENTIFICATION

Traditional patch antennas struggle with narrow bandwidth, lower gain, and inefficient radiation patterns, impedance mismatching, fabrication complexity which affect the overall performance of 5G communication system.

IV. APPLICATIONS

1. 5G Mid-Band Communication

- Triangular antennas can be possible to fine-tune antennas for operating in the 3.5–4.2 GHz range.
- Useful in smartphones, IoT gateways, and small cells due to their compact footprint and multi-band support.

2. Satellite and Aerospace Communication

- Suitable for CubeSats and small satellites due to low profile and lightweight.
- Operates effectively in L/S/X bands, ideal for telemetry, command, and remote sensing.

3. Wearable and Biomedical Devices

- Incorporated into soft, flexible materials, these biosensors support wearable applications for tracking heart rate and glucose levels.
- Works in ISM band (2.4 GHz) for Body Area Networks (BANs).

4. Unmanned Aerial Vehicles (UAVs)

- Used for communication, navigation, or remote sensing payloads.
- Provides low weight and high efficiency at frequencies like 5.8 GHz or 2.4 GHz.

5. Compact Radar Systems

- Ideal for short-range motion detection radar and automotive radar.
- Triangular geometry supports broad bandwidth and directional beam, essential for radar imaging and object tracking.

V. CONCLUSIONS AND FUTURE SCOPE

The literature survey highlights the growing importance of continuous advancements in antenna technology to support the dynamic needs of modern wireless communication systems. Among the various types of antennas available, microwave patch antennas have proven to be a dominant and versatile solution. Their small size, low-profile design, and flexibility make them ideal for a wide range of applications, especially as technology continues to trend towards miniaturization. MPAs are particularly advantageous for integration into modern communication devices, where space is limited, and efficiency is key.

One of the standout features of MPAs is their ability to offer adaptability to different environments and frequencies, which makes them suitable for a variety of wireless communication systems.

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These include Wi- Fi, 5G, IoT, and satellite communications, where the demand for high-speed data transmission and reliable connectivity is ever-increasing. MPAs also help meet the requirements of modern communication systems by providing compact solutions without compromising on performance. The flexibility of MPAs in terms of design and frequency response further contributes to their value, making them adaptable for diverse needs in both consumer and industrial applications. As wireless communication technologies evolve, the need for antennas that are not only compact but also capable of operating at higher frequencies and with wider bandwidths is becoming more pronounced. MPAs are already a solution to this problem, and ongoing research continues to enhance their efficiency, bandwidth, and gain.The literature also reveals that various optimization techniques, such as proximity feeding and the use of new materials, are being explored to increase the performance of MPAs. These innovations have the potential to extend their functionality and application in next-generation wireless systems, such as 5G and beyond.

In summary, microstrip patch antennas are expected to play an increasingly pivotal role in the future of wireless communication. As the demand for more compact, efficient, and versatile antenna systems grows, MPAs are well-positioned to meet these challenges. Continued research and development will help refine their design and performance, ensuring that MPAs remain a crucial component in wireless communication systems for years to come.
Future scope of triangular shape patch antenna are:

1. **Miniaturization for Compact Devices:** Triangular patches offer a naturally smaller footprint than rectangular ones. Ideal for integrated circuits, wearables, IoT sensors, and implantable biomedical devices.

2. **Multiband and Broadband Applications:** By modifying the geometry (e.g., slotted or fractal-based triangles), triangular patches can support multiband or wideband operations. Useful for 5G/6G, Wi-Fi, Bluetooth, and satellite communications.

3. **Reconfigurable and Tunable Designs:** Integration with varactor diodes, MEMS, or PIN diodes can enable frequency reconfigurability. Supports adaptive communication systems and smart antennas.

4. **Array Configurations for Beam Steering:** Triangular patch elements in arrays can enable directional beamforming and MIMO systems. Crucial for advanced radar, automotive, and defense applications.

5. **Flexible and Conformal Antennas:** Future designs will use flexible substrates (e.g., polymers or textiles) for body-worn applications. Suitable for wearable health monitors, military uniforms, and curved surfaces like drones.

6. **Integration with Metamaterials:** Triangular patches can be combined with metamaterials or meta urfaces to improve gain, reduce size, or enable invisibility (cloaking). Relevant in stealth tech, space communication, and advanced sensing.

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[3]. Ezzulddin, Hasan, and Ameen published a research article in 2022 in Simulation Modelling Practice and Theory. Their work dealt with the complete process of designing, simulating, and fabricating a microstrip patch antenna tailored for use in 5G technology.

[4]. Rana et al. (2022) presented a printed segment antenna design for the S-Band, specifically for wireless communication systems. Their simulation and analysis were presented in the Indonesian Journal of Electrical Engineering and Informatics.

[5]. In 2022, Rana and Smieee worked on designing a patch antenna for 5G wireless networks. Their study included design analysis and performance results, posted in the Bulletin of EEI

[6]. Abdulbari and his team proposed a compact patch antenna with a T-shaped design tailored for 5G applications. Their work appeared in a 2021 issue of the Bulletin of EEI.

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[7]. The IEEE International Conference on Semiconductor Electronics (ICSE) in 2022 included a paper discussing patch antenna developments, covering key design features and technical results.

[8]. Mathuri and colleagues designed a dual-band patch antenna with four notch bands aimed at S and C-band operations. Their work was part of the proceedings of the IEEE ICADEE conference held in 2020.

[9]. Mirdha and co-authors introduced a circularled flex antenna for L-band satellite communications. This design was issued in t IJRES in May 2023.

[10]. Hussain et al. developed a dual-band patch antenna intended for WLAN use. Their antenna design and findings were shared in the 2023 edition of Engineering Proceedings.

[11]. Rana, Fahim, Biswas, Mahbub, and Sohel (2023) designed and tested a patch antenna that operates at 3.6 GHz, with their research issued in the TELKOMNIKA journal.

[12]. Kumar and Soni explored an ultra-wideband segment radiator antenna with notch band characteristics, and their study was posted in the MATEC Web of Conferences in 2023.

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