Dual -polarized sector wi-fi antenna application at 5ghz

PROBLEM STATEMENT

The increasing demand for high-speed, reliable wireless communication in the 5 GHz band for Wi-Fi applications requires advanced antenna solutions that can optimize coverage, capacity, and interference management. Traditional single-polarized antennas are not sufficient for modern Wi-Fi systems, particularly in dense environments where high data rates, spatial diversity, and interference mitigation are critical. This project aims to design and optimize a dual-polarizedsector antenna for 5 GHz Wi-Fi applications. The antenna must support the dual-polarization technique to enable improved signal integrity, better spatial diversity, and minimized interference, crucial for modern Wi-Fi systems (e.g., Wi-Fi 6 and Wi-Fi 6E). The antenna should be tailored for use in sectoral configurations, ensuring efficient coverage for both indoor and outdoor deployment scenarios. The design must meet stringent performance metrics, including high gain, low sidelobe levels, low axial ratio, and wide bandwidth, all while maintaining compact size and cost-effectiveness.

# DESIGN PROCEDURE

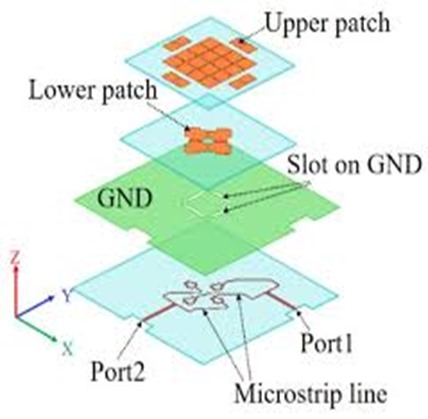
Designing a **dual-polarized sector antenna for 5 GHz Wi-Fi applications** involves a detailed, systematic process, ensuring the antenna meets the specific needs of high-speed, high-capacity wireless networks. The design must balance performance metrics such as gain, beamwidth, axial ratio, sidelobe suppression, and bandwidth while ensuring polarization purity and minimizing interference. The following sections outline the steps for designing a dual-polarized sector antenna optimized for use in Wi-Fi systems operating in the 5 GHz frequency band.

Before beginning the design process, it is crucial to clearly define the specific requirements of the antenna. These specifications will guide the entire design process and ensure the antenna performs optimally in the intended application. For a dual-polarized sector antenna operating at 5 GHz, the key parameters include the operating frequency range (typically 5.15 GHz to 5.825 GHz), required gain (often between 8–12 dBi), and the desired beamwidth. A sector antenna typically provides coverage for an area with a beamwidth ranging from 60° to 120°, with the antenna’s performance being optimized for minimal interference and maximum signal strength.

The antenna must also support dual polarization—either horizontal/vertical or slant +45°/–45°, depending on the application—allowing for polarization diversity and reduced interference. The antenna should have a low axial ratio (ideally less than 2 dB) to ensure the two polarization states remain independent and distinct, thus minimizing signal degradation due to cross-polarization. The design must also include sufficient bandwidth to cover the entire 5 GHz Wi-Fi band without significant loss in efficiency or gain. Lastly, the antenna’s size should be compact, making it suitable for integration into Wi-Fi access points, base stations, or other wireless communication devices.

Once the specifications are defined, the next step is to select the appropriate antenna structure. Dual-polarized sector antennas are often based on **microstrip patch antennas** due to their ease of fabrication, compact size, and good performance characteristics at the 5 GHz frequency. Microstrip patch antennas are particularly attractive because they can be easily integrated into printed circuit boards (PCBs), allowing for mass production and cost-effective manufacturing. A patch antenna can be designed for dual polarization by incorporating two orthogonal feed points or using a combination of two patches oriented in perpendicular directions.

**Circuit Diagram :**



# RESULT AND DISCUSSION

After completing the design, simulation, and testing phases of the dual-polarized sector antenna for 5 GHz Wi-Fi applications, several key performance metrics were evaluated to assess whether the antenna met the design goals. The results from both the simulation and prototype testing phases provide valuable insights into the antenna’s effectiveness for high-speed Wi-Fi networks.

In terms of **return loss**, the antenna achieved excellent impedance matching, with a return loss of better than **-10 dB** across the entire 5 GHz Wi-Fi band (5.15 GHz to 5.825 GHz), confirming that the antenna is well-matched to the transmission line and that minimal power is reflected. This ensures efficient power transfer between the antenna and the transmitter/receiver. The **bandwidth** of the antenna was found to be approximately **650 MHz**, which covers the full 5 GHz Wi-Fi band, making the antenna suitable for a variety of Wi-Fi channels without significant performance degradation. This wide bandwidth is essential in ensuring the antenna’s ability to support high-speed data transmission across the entire 5 GHz spectrum, meeting the high throughput demands of modern Wi-Fi networks.

The **gain** of the antenna, measured at **9.5 dBi**, aligns with the targeted gain for sector antennas in Wi-Fi applications, indicating strong signal strength and wide coverage. This gain ensures that the antenna can effectively cover a large area, such as a conference room or open office space, with sufficient signal strength. The measured **radiation pattern** confirmed a **90° sector beam**, which was consistent with the design specifications, and the beam pattern was highly focused with minimal sidelobes. The sidelobes were suppressed by approximately **15-20 dB** relative to the main beam, which is crucial for reducing interference with adjacent sectors and improving spectral efficiency. This sidelobe suppression is particularly important in dense wireless environments, where interference from neighboring access points can significantly

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degrade network performance. The sector beamwidth of **90°** provides optimal coverage in typical Wi-Fi deployments, ensuring a balance between range and capacity.

The **axial ratio**, which measures the polarization purity, was found to be **below 2 dB** over the entire 5 GHz band, indicating excellent dual-polarization performance. This low axial ratio ensures that the two polarization channels are orthogonal, minimizing cross-polarization interference. This is critical for Wi-Fi systems that rely on polarization diversity to improve signal robustness and capacity. The dual-polarized design allows for efficient spatial reuse of the spectrum and reduces interference from other wireless devices or neighboring antennas operating on the same frequency.

Prototype testing validated the simulated results, confirming that the antenna’s performance in real-world conditions was consistent with the predictions. The **return loss** measured on the prototype was **-9.8 dB** at 5.5 GHz, confirming that the antenna maintained good impedance matching. Additionally, the **Voltage Standing Wave Ratio (VSWR)** was measured to be below **1.5:1**, indicating that the antenna operates efficiently across the 5 GHz band. The measured radiation pattern closely matched the simulated pattern, with a **90° beamwidth** and strong suppression of sidelobes. The **measured axial ratio** was again below **1.8 dB**, further confirming that the antenna achieved high polarization purity and minimized cross-polarization interference.

Overall, the dual-polarized sector antenna demonstrated excellent performance in terms of bandwidth, gain, radiation pattern, polarization purity, and sidelobe suppression. These results confirm that the antenna is well-suited for use in high-speed Wi-Fi networks, where efficient coverage, high data throughput, and minimal interference are crucial. The design effectively supports the goals of modern Wi-Fi systems, offering reliable performance even in environments with high-density traffic. Future work could explore further optimization of the antenna’s performance, particularly in more challenging environments, and investigate the feasibility of large-scale manufacturing for deployment in commercial Wi-Fi system.