ABSTRACT

To meet the increasing demand for high data rates, research in millimeter-wave (MMW) frequency ranges, spanning from 30 to 300 GHz, has gained significant attention. Among these, the V-band and W-band are of particular interest due to their diverse applications in wireless communication, imaging, radar, space communication, and security screening. Despite extensive research on leaky-wave antennas (LWAs) over several decades, substantial challenges persist in developing high-frequency LWAs suitable for these bands. This research aims to delve into the theoretical foundations, design methodologies, and practical implementations of high frequency V and W-band travelling wave antennas for various applications by focusing on innovative design approaches to enhance performance and fabrication feasibility.

The primary objective of this research is to design a high-gain, narrow-beamwidth, waveguide based LWA operating in the W-band frequency range. The circularly polarized antenna will be designed into a WR-10 waveguide and will utilize a polarization converter-based architecture to achieve circular polarization. The focus is to maximize efficiency for millimeter-wave applications, ensuring robustness and improving high-frequency communication capabilities.

Additionally, this research aims to develop a low-profile dual circularly polarized antenna based on a fully metallic waveguide for satellite communication. A key consideration is ensuring ease of fabrication at W-band frequencies while maintaining scalability to sub-terahertz (THz) frequencies. The proposed design should provide a wideband operating frequency with an axial ratio bandwidth exceeding 10% at the 94 GHz frequency band.

Another critical objective is to design and characterize a fixed-frequency beam scanning antenna operating within the 86 GHz - 90 GHz range. This antenna will incorporate a mechanical tuning mechanism within a waveguide-based architecture to enable forward-to-backward beam scanning at a fixed frequency. The design approach will emphasize innovation in waveguide-based beam steering while ensuring ease of fabrication.

Finally, this research focuses on designing a fully metallic waveguide-based V-band antenna with circular polarization capabilities. The antenna must exhibit high efficiency, narrow beamwidth, and high gain, while also being robust enough to withstand harsh environmental conditions, making it suitable for satellite communication. The design should be scalable to both higher and lower frequencies, ensuring versatility in future applications.

By addressing these challenges, this research aims to contribute significantly to the advancement of millimeter-wave antenna technology, offering efficient and scalable solutions for high-frequency communication and space applications.