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Thesis Title: Study of Dual-Polarized Center-Series-Feed Parallel-Plate Waveguide Slot Array Antennas

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Under the supervision of Professor Hirokawa Jiro

Thesis Outlines:

Chapter 1: Introduction

This chapter introduces the motivation and scope of the research, focusing on the design and implementation of dual-polarized center-feed parallel-plate waveguide slot array antennas. It highlights the challenges in achieving high performance, efficiency, and bandwidth in these antennas and outlines the objectives of the dissertation.

Chapter 2: Radiating Structures for Dual-Polarized Antennas

In this chapter, various radiating structures for dual-polarized center-feed parallel-plate waveguide slot array antennas are explored. Through simulations, it is found that the slot-hole radiating structure exhibits narrow bandwidth and compatibility issues with the waveguide's coupling slots. As a result, the co-linear slot pair is identified as a more suitable radiating unit for dual-polarized antennas, and this structure is adopted for further antenna designs in subsequent chapters.

Chapter 3: Dual-Polarized Antenna Design at 24.5 GHz

This chapter presents the design of a dual-polarized parallel-plate waveguide slot array antenna operating at the 24.5 GHz band, using a single-layer waveguide with four feeding waveguides. By comparing tilted coupling slots and centered longitudinal coupling slots, the latter demonstrates superior matching and radiation performance. The antenna maintains a radiation efficiency above 95% across 23.0–26.0 GHz, with peak directivity of 33.14 dBi and aperture efficiency of 54%. The fabricated prototype achieves an impedance bandwidth of 13.0% and a realized gain of 31.85 dBi. Additionally, a method to improve cross-polarization discrimination (over 40 dB) by adjusting the feeding phase and slot arrangement is proposed, though it slightly increases sidelobe levels.

Chapter 4: Difference-Beam Operation

This chapter discusses the antenna's difference-beam operation, achieved by adjusting the excitation phase of two waveguide feeders for each polarization. The antenna can switch between sum-beam and difference-beam modes, demonstrating a deep null depth of -47.7 dB. The measured gain of the sum beams at 24.5 GHz is 31.3 dBi, with over 15 dB isolation between sum and difference modes. An improvement in the isolation to over 22 dB is achieved using a virtual monopulse comparator.

Chapter 5: Partially Corporate Feeding Network

In this chapter, a partially corporate feeding network is proposed for the dual-polarized antenna at 22 GHz. This network divides the antenna into subarrays, reducing the wave traveling length in the waveguide. A dielectric-filled crossover is introduced to isolate feeding waveguides for different polarizations. While achieving a wider working bandwidth and improved impedance matching, the crossover introduces field vibrations that suggest further refinement is needed. In addition, a novel

coupling slot structure with an iris matching mechanism is proposed to enhance the antenna's impedance and bandwidth performance.

Chapter 6: Conclusion and Future Work

This chapter summarizes the thesis's key contributions, highlighting the innovative designs that improve the performance of dual-polarized center-feed parallel-plate waveguide slot array antennas. Suggestions for future research include refining the corporate feeding network and reducing mutual coupling between radiating units.