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論 文 要 旨

THESIS SUMMARY

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要旨（和文 2000 字程度）
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In recent years, there has been an increasing interest in developing simplified designs for dual-polarized and monopulse planar waveguide slot array antennas due to the rising demand for high-speed, reliable, and efficient communication systems. Both types of antennas struggle with balancing performance and structural complexity. Parallel-plate waveguide slot array antennas, using a single-layer parallel-plate waveguide as the radiating panel, offer a potential solution for achieving high-performance in dual-polarized and monopulse array antennas. This doctoral dissertation introduces a series-feed dual-polarized parallel-plate waveguide slot array antenna, which can also function as a monopulse slot array with a difference beam operation mode. Additionally, a partial corporate feed network is proposed to enhance the radiation bandwidth of the antenna array.

Chapter 1 provides an overview of the background and recent achievements in dual-polarized antennas, monopulse antennas, and parallel-plate waveguide slot arrays. This dissertation focuses on the design and optimization of series-feed and partial corporate-feed dual-polarized parallel-plate waveguide slot array antennas with simplified structures and minimal fabrication challenges.

Chapter 2 introduces different radiating structures for a series-feed dual-polarized parallel-plate waveguide slot array antenna. It details the simulation models and results for the slot-hole element, subarray, and complete dual-polarized array. It is found that a significant limitation of the slot-hole radiating structure is its narrow bandwidth. Simulation results indicate that the 50% coupling element covers only a 6.1% matching bandwidth with reflection below -10 dB. For the 1-D subarray simulation, the reflection at the center frequency of 24.5 GHz is -7.28 dB. Another limitation is that the hole is milled at the bottom of the parallel-plate waveguide, which conflicts with the coupling slots between the waveguide feeders and the parallel-plate waveguide. Consequently, the slot-hole radiating element is not ideal for dual-polarized parallel-plate waveguide slot array antennas, and the co-linear slot pair radiating structure is adopted in subsequent chapters.

Chapter 3 describes the design of a dual-polarized parallel-plate waveguide slot array antenna operating at the 24.5 GHz band. This design utilizes a single-layer parallel-plate waveguide structure with four feeding waveguides. The design process includes detailed simulations of the co-linear radiating slot pair array, with simulated results for individual radiating slot pairs and the 1-D radiating subarray. The study compares feeding waveguides with conventional tilted coupling slots and centered longitudinal coupling slots, revealing that the latter offers superior matching and radiation performance. Simulations demonstrate that the antenna maintains a radiation efficiency above 95% across the frequency range of 23.0 GHz to 26.0 GHz, with a peak directivity of 33.1 dBi at 24.5 GHz and an aperture efficiency of 54%. The antenna prototype is validated through CNC milling fabrication and extensive measurements, achieving an impedance bandwidth of 13.0% and a peak realized gain of 31.9 dBi, with an antenna efficiency of 40%. Additionally, a method to enhance cross-polarization discrimination by adjusting the feeding phase and slot array

arrangement is proposed, achieving over 40 dB of cross-polarization discrimination, though with a slight increase in sidelobe levels.

Chapter 4 explores the difference-beam operation of the antenna introduced in Chapter 3. By adjusting the excitation phase of two waveguide feeders for each polarization, the antenna can seamlessly switch between difference-beam and sum-beam operation. Experimental results show a deep null depth of -47.7 dB, with a measured reflection bandwidth of 13.3% for difference modes and approximately 13% for sum modes, where the reflection is below -10 dB. The measured realized gain of the sum beams at 24.5 GHz is 31.3 dBi for both polarizations. The isolation between sum and difference modes is over a modest value of 15 dB, which is improved to over 22 dB with the implementation of a virtual monopulse comparator in the calculation study on the isolation improvement.

Chapter 5 introduces a partially corporate feeding network for the dual-polarized parallel-plate waveguide slot array antenna operating at 22 GHz. This corporate feeding network divides the radiating slot array into four subarrays, reducing the wave traveling length inside the parallel-plate waveguide by half. A dielectric-filled crossover is designed to isolate the feeding waveguides for different polarizations. Simulations indicate that the antenna has an impedance bandwidth of 12.1%, where the reflection is below -10 dB, a 3-dB gain bandwidth of 4.77%, and a peak gain of 34.28 dBi, with a moderate antenna efficiency of 55%. Although the crossover is optimized to minimize slot spacing, it still introduces more field vibrations within the parallel-plate waveguide, suggesting that further refinement of the feeding network could enhance performance. The novel coupling slot structure with an iris matching mechanism proposed in this chapter, consisting of one inductive and one capacitive wall, further improves the antenna's impedance and radiation performance.

Chapter 6 concludes the dissertation with a summary and perspectives on future work. Potential future research includes measurement verification of the partial-corporate-feed parallel-plate waveguide slot array antenna, the development of a new corporate feeding network to mitigate the long line effect in the feeding part, and designing a new radiating slot structure to reduce mutual coupling between orthogonally placed radiating units.