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論文 / 著書情報
Article / Book Information

題目(和文)	ギャップ導波路と垂直並列給電平行平板を用いたスロットアレーアンテナの研究
Title(English)	Study of Slot Array Antennas using Gap Waveguides and Perpendicular Corporate-Feed Parallel Plates
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	電気電子 系 電気電子 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（Engineering）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Corporate-feed waveguide slot antennas offer superior bandwidth compared to serial-feed ones. However, fabricating these antennas in the millimeter-wave band or beyond is challenging due to their complex structure and the need for high-quality bonding or welding techniques to ensure strict electrical contact between layers. This doctoral thesis addresses these fabrication challenges while enhancing the performance of millimeter-wave full-metal slot array antennas by using gap waveguides and perpendicular corporate-feed parallel plates. Four different antennas are presented to demonstrate this approach.

Chapter 1 first introduces the background, application and development of full-metal waveguide slot antenna, then introduces the gap waveguide technology and perpendicular corporate-feed parallel-plate slot arrays. The motivation of this dissertation comes up, which focuses on simplifying the fabrication and improving the performance of corporate-feed slot array antennas by using gap waveguides and perpendicular corporate-feed parallel plates.

Chapter 2 presents a wideband full-metal sidewall-loaded magnetoelectric dipole array antenna fed by combined ridge-groove gap waveguides. The introduction of sidewalls around metal pillars and increasing their height to 0.36 free-space wavelength results in a substantial bandwidth enhancement to 33% for reflection below -15 dB of the 2 × 2-element magnetoelectric dipole subarray. The eigenmode analysis confirms the effectiveness of the taller pins and sidewalls in achieving this broadband performance. Stepped transformers are utilized in designing wideband ridge-to-groove and groove-to-ridge junctions, effectively extending the bandwidth to cover the entire Q-band (33 GHz-50 GHz) for reflection below -15 dB. An 8 × 8-element sidewall-loaded magnetoelectric dipole array was fabricated using computer numerical controlled milling technology in the Q-band. The measured results showed a bandwidth of 35.9% for reflection < -10 dB. Additionally, the gain bandwidth where the antenna efficiency exceeds 75% is 32.5%.

Chapter 3 introduces perpendicular-corporate-feed parallel-plate slot array antenna based on an H-plane groove gap waveguide with interlaced triangular pins. The unit cell with interleaved triangular pins offers a wide operating bandwidth covering the V-band (50 GHz-75 GHz). The novel groove gap waveguide utilizing interlaced triangular pins, effectively addresses manufacturing challenges associated with techniques like computer numerical controlled milling by creating more space between periodic pins.

Furthermore, it achieves a lower cut-off frequency compared to traditional designs within limited spaces. Based on this concept, wideband T- and H-junctions along with input transitions are successfully designed and implemented in the corporate-feed network. By incorporating irises and stepped coupling slots, and introducing the slit position as a new degree of freedom, the bandwidth of the 2 × 2-parallel-plate slot subarray is broadened to 28.3% for reflection below -14 dB. An 8 × 8-slot array is designed, and fabricated by computer numerical controlled milling in the V-band, demonstrating a widened bandwidth of 26.3% for reflection below -10 dB. Also, the antenna efficiency exceeds 75% with a wide bandwidth of 23.6%.

Chapter 4 introduces a wideband, low-profile, and straightforward perpendicular corporate-feed parallel-plate slot array antenna with long gratings. The study includes a thorough comparison of three simple, low-profile full-metal 2 × 2-parallel-plate slot subarrays. The third design demonstrates superior reflection and gain bandwidth while maintaining a low profile. Notably, the introduction of two additional matching networks—an iris in the feeding waveguide and long gratings—significantly enhances the impedance matching bandwidth of the subarray from 10.8% to an impressive 26.8%. Furthermore, these long gratings contribute to a 6.1% improvement in the 3 dB-down gain bandwidth by adjusting the aperture field distribution. The antenna, featuring 1 × 16-long gratings, achieves a bandwidth of 31.5% for reflection below -10 dB, an antenna efficiency of 70% over a 25.5% bandwidth, and a profile height of 0.83 free-space wavelength by diffusion bonding technology only for the feeding part.

Chapter 5 firstly proposed a virtual cavity-based full-metal perpendicular-corporate-feed dual-polarized waveguide slot array antenna to achieve both simplicity and performance improvement. The conventional intricate metal-cavity-backed structures are removed and replaced with a virtual cavity with periodic boundary walls. Wide crossed radiating slots and a modified orthomode transducer with enhanced isolation are developed within the 2 × 2-slot subarray, leading to significant bandwidth improvements without increasing structural complexity. A 16 × 16-slot corporate-feed dual-polarized array antenna featuring a simplified structure, low profile (1.4 free-space wavelength), and enhanced performance is realized using diffusion bonding technology exclusively for the feeding circuits. For reflection below -10 dB, the measured overlapped bandwidth is 8.6%, which is slightly lower than the simulated 13.7% because of the 35 μm over-etching. Between 56.0 GHz and 67.0 GHz, the isolation is more than 50.8 dB. For both polarizations, the antenna efficiency exceeds 60.0% over a 9.8% overlapping bandwidth.

Chapter 6 provides a comprehensive summary to conclude the dissertation and offers perspectives on potential future work. These future directions include the design of high-gain (over 45 dBi) and high-efficiency array antennas with high-order parallel-plate slot subarrays, the development of wideband circularly-polarized 2 × 2 parallel-plate slot subarrays, and the integration of full-metal parallel-plate slot arrays with functional surfaces.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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