

論文 / 著書情報
Article / Book Information

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論文要旨

THESIS SUMMARY

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| 系・コース： Department of, Graduate major in | 電気電子 電気電子 | 系 コース | 申請学位 (専攻分野)： Academic Degree Requested | 博士 Doctor of | (Philosophy) |
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

Relying on the advantageous perpendicular-corporate feed configuration, several high-performance multi-layer slot array antennas are realized via simple parallel-plate geometries. Rapid analysis based on eigenmode expansion method is conducted on the 2×2 -slot subarrays. Integrated with the time-efficient analysis, optimum dimensions of the subarrays are obtained by an optimization tool. A full corporate feed network made from hollow waveguide is utilized in the bottom layer to feed the subarrays uniformly. Finally, for theses large-scale planar parallel-plate array antennas, wideband, high-gain, and low-reflection characteristics are realized.

Chapter 1 gives introduction of planar waveguide slot array antennas and reviews state-of-art waveguide subarray designs based on the perpendicular-corporate-fed 2×2 -element configuration.

Chapter 2 clarifies the process of applying the eigenmode expansion analysis by method of moments (MoM) on the perpendicular-corporate-fed parallel-plate slot subarray. Five steps from the modeling and formulation of the problem to the final calculation of the antenna characteristics are detailed. Before realizing the analysis on the target double-layer 2×2 -wide-slot subarray, preliminary cases with single radiating slot or narrow slots are analyzed as the foundations. The accuracy of the proposed analysis of the model is validated by good agreement between the analyzed results and the simulated ones obtained by a general-purpose 3D-FEM based simulator. The convergence and trade-off between the efficiency and accuracy are discussed as well. Using several fundamental basis functions and expanded eigenmodes, the electromagnetic analysis on the subarray model can be completed fast and accurately.

Chapter 3 illustrates the application of the analysis on the optimum designs of a double-layer and a triple-layer subarrays which have stratified air regions with dielectric loaded between parallel slotted plates. Based on the MoM analysis, simultaneous optimization of all dimensions of the models becomes feasible. A micro genetic algorithm (GA) method is used for optimizing the bandwidth instead of a standard GA. The double-layer subarray shows a bandwidth of 13.1% with reflection less than -14 dB, much enhanced from the 7.7% of the triple-layer conventional design and the 11.4% of the four-layer conventional design. Fed by a corporate feed circuit made from cascading T-junction power dividers, a 14.6% bandwidth is realized for a 16×16 -slot array. The radiating layer of the array is composed of stacked separate plates fastened by screws, whereas the feed layer made from hollow waveguide is fabricated by diffusion bonding technology. The measured bandwidth with reflection lower than -10 dB is 13.2%. The difference between the simulation and measurement results mainly from error in fabrication or assembly of the feed part. A high measured gain over 30 dBi is obtained over 57 GHz – 66 GHz.

Using the optimized triple-layer subarray with bandwidth of 16.0%, a 16×16 -slot array with simulated 15.6% bandwidth for reflection less than -14 dB is designed. Even though the bandwidth covers 57 GHz – 66 GHz (14.6%), the array is not fabricated because the improvement from the double-layer counterpart is not significant enough.

Chapter 4 presents several optimum designs of all-metallic triple-layer parallel-plate 2×2 -slot subarrays. A preliminary case based on the triple-layer model getting rid of the dielectric plate is analyzed by the MoM analysis and optimized firstly. The bandwidth seems to increase from that of the dielectric-loaded one, but there is gain deterioration around 56.0 GHz in the band of 57 GHz – 66 GHz. Gratings are loaded into an air region to eliminate the gain degradation due to a high-order mode resonance. A simulated 18.6% bandwidth with reflection less than -14 dB is obtained by the all-metallic grating-loaded subarray. Replacing the E-bend of the conventional feed circuit by a stage-type one, the bandwidth of the feed part increased from 15.1% for reflection lower than -20 dB to 17.5% for reflection lower than -25 dB. The simulated bandwidth of the 16×16 -slot array is 18.2% from 56.1 GHz to 67.3 GHz. Through the same fabrication and measurement processes, the fabricated array shows a bandwidth up to 19.2% with reflection less than -10 dB. The degradation of the reflection level from the simulated results is due to the deformation of air thickness as the separate plates are assembled with limited number of screws at the margins. High aperture efficiency over 90% and antenna efficiency over 70% are realized over the full impedance band.

Based on the MoM analysis, another all-metallic triple-layer subarray is analyzed and optimized in the X-band especially for low-reflection performance. Similar to the preliminary case of this chapter, a same problem of high-order mode resonance in the air region occurred. Same solution of loading gratings with stubs is adopted according to the specific field distribution of the mode. The grating-stub-loaded subarray shows a bandwidth of 12.7% (9.17 GHz to 10.42 GHz) with reflection less than -20 dB. Combined with a feed circuit also modified for low reflection, a 16×8 -slot array is designed with reflection less than -20 dB over 9.2 GHz – 10.4 GHz.

In Chapter 5, this study is summarized and future issues to address are presented.

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。

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