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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Parallel-plate slot array antennas are attractive in centimeter- and millimeter-wave applications due to their intrinsic advantages of high gain, high antenna radiation efficiency, low losses, compact structure, and high-power capability. Compared to the conventional planar slotted array antenna configuration consists of array of juxtaposed single-mode waveguides, the suppression of the sidewalls reduces the manufacturing cost and enables a more flexible radiating element arrangement. However, the oversized characteristic of the radiating waveguide makes the parallel-plate antenna difficult to achieve high aperture efficiency. The existed methods to increase the aperture efficiency, e.g., employing hard surface or corporate feeding scheme, has the limitations of high dielectric loss and complicated structure, respectively. This study investigated the waveguide feeder of a simple double layer parallel-plate slot array antenna and proposed several possible solutions on improving its aperture efficiency. One of the objectives of this dissertation is to develop a fast analysis method of the waveguide feeder with tilted coupling slots for an oversized rectangular slot array. The other objective is to investigate new feeding structures for achieving a further aperture efficiency improvement. Firstly, a novel feeding network which adopting collinearly centered longitudinal coupling slots is proposed. Afterwards, capacitive elements is introduced into the feeding structure to eliminate the inductive effect associated with the coupling wall.

Chapter 1 discussed the background and applications of the parallel-plate slot array antenna. The antenna structure of this dissertation is illustrated, and the operation principle is explained.

Chapter 2 introduced the basic principle of Galerkin's MoM which is used in the coupling slot analysis and design. Individual coupling slots are analyzed by the MoM and HFSS. The calculation time is only 7 seconds by MoM which is much faster than that of 180 seconds by HFSS. Equivalent relationships of various design parameters are introduced between the MoM and HFSS models for compensating the inaccuracy assumptions in MoM analysis. The calculation results show a good consistency between the two analysis methods after employing the equivalent relationship.

Chapter 3 presented the fast-speed MoM design procedure of the waveguide feeder with reflection-canceling inductive walls inside, which has introduced in Chapter 1. The MoM analysis introduced in Chapter 2 is applied in the individual coupling slot design and then the slot array design.

MoM shows a fast speed with only 20 seconds to analyze the array with 14 slots, while it takes 4 hours by HFSS. The superiority in the calculation speed of MoM makes it possible for an accurate array design that includes the mutual coupling effect within the feeding waveguide region, which is impractical to realize in HFSS design. The MoM-designed parameters of the slot array are converted to HFSS equivalent parameters as the fabrication parameters by using equivalent relationships stated in Chapter 2. The calculation results of MoM and HFSS slot array models show a small difference, which demonstrates the validity of the equivalent relationships. The designed waveguide feeder with the antenna panel was tested by measurements. It shows a 3-dB amplitude fluctuation level and 45-degree phase fluctuation level in the parallel plates, which confirm the operation of the feeder with uniform in-phase excitation. A peak directivity of 36.0dBi and 67.7% aperture efficiency is obtained at 9.65GHz.

Chapter 4 proposed a novel feeding configuration by altering the tilted coupling slots to collinearly centered longitudinal slots, which aims to reduce the field ripple in the parallel plates. Coupling walls are inserted in the waveguide to produce asymmetry for an appropriate excitation of each slot. The improvement in the aperture efficiency by applying centered non-tilted coupling slots is initially confirmed by a feasibility study. The feeding network with inductive matching walls is then designed by HFSS and measured. A peak directivity of 37.05dBi and 87.2% aperture efficiency is achieved at 9.65GHz. A 21% aperture efficiency enhancement is obtained compared to the conventional feeding structure in Chapter 3. Reflection level is less than -16dB within 9.5GHz-9.8GHz. The discrepancy between measurement and simulation is compensated by adjusting the lengths of all the coupling slots.

Chapter 5 proposed a waveguide feeder with iris-excited longitudinal slots for further reducing the slot spacing. The inductive reflection-canceling walls in the previous design of Chapter 3 are replaced by capacitive walls. The feeding waveguide is designed by HFSS. A peak directivity of 37.1dBi and 87.6% aperture efficiency is achieved at 9.65GHz. A reflection level less than -24dB is obtained within 9.5GHz-9.8GHz. The total length of the feeding waveguide is effectively reduced from 696mm to 683mm, which makes the antenna more compact. However, the iris structure is not suitable for manufacturing since the capacitive wall and the coupling wall touch with each other with a misalignment. A further investigation on other possible feeder configurations is conducted which makes the inductive and capacitive element are successfully separated.

In Chapter 6, the study is summarized and the remarks for the future investigations are presented.