論文 / 著書情報
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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	電気電子工学 専攻	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 ）

This dissertation studies the Radial Line Slot Antenna (RLSA) – a unique slotted array antenna with oversized parallel plate waveguides (PPW) as its feeding network. The objective of this dissertation is to develop a stable design/ analysis method to control the cylindrical travelling waves operation in oversized PPW. It includes the optimizations of feeding structures and oversized waveguide structures, and the slot array synthesized techniques.

Chapter 1 reviews the history of antennas and wireless communications and the development of waveguides, followed by the state of art of RLSA. Existing problems with oversized PPW are addressed, that is, the generation of higher order modes that causes instability, travelling wave operation inside PPW that results in narrow bandwidth, and the electrically large RLSAs (the diameter > 40 wavelengths) that require simple design/ analysis procedure.

Chapter 2 challenges the rotational symmetry design policy of RLSA, by proposing a RLSA with elliptical aperture and associated elliptical beam. To check the feasibility of this asymmetry design, an elliptical aperture with a typical ratio 2:1 was selected as the design target. The simple coaxial feeding structure was modified to direct the power equally (4:1) in each radial ρ-direction. The antenna aperture was then modified to effectively radiate the 4:1 directive power that created by the new feeding structure; and it has a quasi-elliptical shape, which closes to the desired 2:1 ellipticity. Finally, I synthesized the slot array for both radialρ- and circumferential ϕ- directions to realize uniform aperture illumination. Based on these analyses, 22 wavelengths x 11 wavelengths elliptical RLSA was designed and fabricated at 22GHz. The desired 2:1 elliptical beam shape was produced precisely; with 3dB beam-width are 4.9 and 2.5 degrees for 90 and 0 degrees cut-planes.

Chapter 3 reports a high-gain, light-weight RLSA for Hayabusa 2, a space exploration satellite designed by JAXA. At 32GHz, more than 44.1dBi gain is required for a high quality link between ground and space. To satisfy this very high-gain, a 900mm (96 wavelengths) diameter circular aperture was proposed, and the expected net weight of the antenna is about 1kg.

Honeycomb structure, an aerospace used structure, is utilized for the PPW to reducing the antenna weight. At high frequency, anisotropic problem arises with honeycomb structures whose cells are larger than a half wavelength. Finer cell size – 1/8 inch (0.34 wavelength) honeycomb structure was investigated and it produced good results in term of isotropy. To construct the honeycomb structure with cell size as fine as 1/8 inches, Nomex® fibre was the only viable material, regardless of its lossy property (loss factor α_l = 0.014 ~ 0.018dB/mm). To ease the fabrication process, adhesives and skin layers were added to the Nomex® honeycomb core, and that creates a four layer dielectrics waveguide. EM analysis of this complicated structure and an electrically large aperture (96 wavelengths) with a few ten thousands slots is difficult to conduct by commercial tools such as HFSS or full-wave method of moments (MoM). Therefore, I proposed an equivalent double layer model for the multilayer waveguide and a design/ analysis procedure based on MoM to predict the antenna's performance. After several trials, I successfully designed and fabricated the RLSA for Hayabusa 2 flying model. At 32GHz, the antenna gain is 44.6dBi, and its weight is only 1.16kg.

Chapter 4 synthesizes the slot array to maximize the antenna gain in case lossy materials (α_l > 0.01dB/mm) were used to fill the PPW, such as the Hayabusa 2 case. By properly control the coupling factor, I can suppress the energy that is absorbed by lossy materials. Based on an energy conservation model in PPW, coupling factor distribution to maximize the antenna gain was derived. Three 400mm (80 wavelengths) diameter RLSAs were designed at 60GHz, following different coupling factor formulations. RO4003C™, a lossy material (α_l = 0.09 ~ 0.11dB/mm) was used to fill the PPW. Measurement results agree with my predictions, that is, the design following the maximum gain coupling factor produce highest gain. In this particular case, about 1dB gain enhancement was achieved.

Chapter 5 introduces a 60GHz Gigabit Access Transponder Equipment, that can provide error free and high speed communication in short ranges. Array antennas with a large number of elements are required to create constant EM field areas. In short range communication, the inter-symbol interference problem arises as the signals coming from different places on the antenna aperture overlap each other. To partly deal with this problem, I proposed an amplitude taper design to diminish the contributions of signals near the edges. Calculated field strength suggests the improvement of the field uniformity when amplitude taper was applied, with less than 10dB deviation in a 3D zone up to 10 meter from a 200mm (40 wavelengths) circular aperture. A prototypical RLSA was designed following my proposed linear amplitude taper; and measured field intensity in short range shows promising results.