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論文要旨

THESIS SUMMARY

専攻 : Electrical and Electronic Engineering
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専攻

申請学位 (専攻分野) : 博士 (Philosophy)
Academic Degree Requested Doctor of
指導教員 (主) : Jiro Hirokawa
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要旨 (英文 800 語程度)
Thesis Summary (approx.800 English Words)

Currently, the conventional microwave band below 10 GHz has been heavily utilized and is going to reach its saturation point because of the ever-growing demand of booming wireless applications that require gigabit per second (Gbps) and higher data speeds. To cope with this challenge, this study makes efforts on the functional-circuit integration to waveguide slot array antennas in the millimeter-wave band. To be specific, the integration of filtering functionalities for E-band point-to-point communication, the incorporation of monopulse processing capability for E-band monopulse tracking, and the simultaneous generation of multiple orbital angular momentum (OAM) modes for V-band OAM-mode multiplexing, have been investigated. Different functional circuits associated with different integration scenarios have been studied. It has been verified that by properly designing the functional circuit and then optimally integrating with the feeding circuit, the antenna can work very well with specific functionality.

Chapter 1 reviews the application background and the state-of-the-art design techniques of waveguide slot array antennas for the millimeter-wave applications. It is shown that the traditional millimeter-wave waveguide antennas are mainly used for radiation without implementing any other functionality in their feeding networks. Consequently, the feasibility of integrating functional circuit to waveguide slot array antennas for different millimeter-wave wireless applications has been introduced.

Chapter 2 presents the plate-laminated waveguide filters in diffusion bonding technology for the first time and shows their uses in the integration with a corporate-feed slot array antenna for E-band ultra-high capacity point-to-point communications. First, a single cavity resonator model is studied and the measured high unloaded quality of 2121 at 79.07 GHz indicates its potential in the design of low-loss filters. Consequently, a sixth-order T-shaped cavity bandpass filter that is comprised of ten cavity resonators is developed. It exhibits an insertion loss of 0.4 and 0.3 dB at 78.5 GHz at two output ports, a 3-dB fractional bandwidth of 20.5% as well as a small in-band amplitude/phase difference. Then, a fourth-order bandstop filter based on a band-rejection element is presented. It provides a high rejection level of 55 dB at 78.5 GHz, while an insertion loss of 0.44 and 0.28 dB at 73.5 and 83.5 GHz. The architectures of the proposed filters show attractive compatibility properties for integration. Finally, the proposed filters are fully integrated into a corporate-feed circuit of a 16×16 -element slot array antenna without an interconnection circuit. With the seamless integration, the proposed building blocks demonstrate well-preserved high efficiency (only a low loss is introduced by the filters) and unchanged radiation characteristic (low side-lobe level, low cross polarization, and high directivity) in the designed passband, as well as specified band-stop performance.

Chapter 3 presents the design and characterization of an E-band 16×16 -slot monopulse array antenna

with full-corporate-feed fabricated by the diffusion bonding of laminated copper plates. The antenna is multi-layered, and consists of vertically-interconnected radiating elements, a corporate-feed circuit and a comparator. It has four input ports for different excitations. Sum and difference beams in different cut-planes for monopulse operation can be generated. The antenna has a quasi-planar profile, and a total size of $13.31 \lambda_0 \times 13.31 \lambda_0 \times 1.52 \lambda_0$ (λ_0 is the wavelength at the design frequency of 78.5 GHz). The antenna demonstrates a wide operation bandwidth of 17.2 (70–87.2) GHz for VSWR < 2. At 78.5 GHz: 1) for the sum beam, there is a 32.6-dBi realized gain (83% antenna efficiency) and a 33.3-dBi directivity (95% aperture efficiency); 2) for the difference beams in the E -, H -, 45° -, and 135° -planes, the null depths are -53.0 , -58.0 , -57.8 , and -65.6 dB, respectively. Across the full operation band where the sum main-beam and difference null are able to consistently point at the boresight, the antenna also demonstrates excellent performance in terms of high gain, high efficiency, high isolation, low cross-polarization, and distinguished monopulse capability.

Chapter 4 presents the feasibility of simultaneously generating multiple OAM modes by using a radial line slot antenna (RLSA) which is fed by an OAM beam-switching circuit network. The OAM beam-switching circuit is placed at the lower layer and it is based on a post-wall waveguide structure. It has four input ports and it can launch different progressive phase states in the RLSA parallel plate waveguide. The RLSA is fed by the OAM beam-switching circuit through four open posts which are concentric to the RLSA center. Considering the application background of V-band non-far region communication, a Gaussian amplitude taper and a convex-lens phase taper have been applied on the antenna aperture. The effect of the aperture phase-taper on the channel capacity in OAM-mode multiplexing has also been investigated. The simulated results show that, at the design frequency, three OAM-mode states are generated maintaining an acceptable rotational symmetry.

Chapter 5 presents the conclusions and the future prospects of this study.

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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