論 文 の 内 容 の 要 旨

論文題目　Dual Polarization Travelling-Wave Antenna with Centralized Radio-Frequency Transmitting/Receiving System for Synthetic Aperture Radar in Small Satellites
（小型衛星搭載の合成開口レーダー用の集中型送受信システムを有する２偏波対応進行波型アンテナ）

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Active radar sensors have certain advantages over passive optical sensors for space-based remote sensing. They, however, are difficult to accommodate on a small satellite bus primarily due to large mass, size of the antenna system. To make the system compact and lightweight, a dual-polarization traveling-wave antenna with centralized high-power Radio Frequency (RF) source is proposed as the antenna system candidate.

This antenna utilizes panel made of parallel aluminum plates separated by honeycomb dielectric and orthogonal radiating slot-pairs. The advantage of this type of antenna is that orthogonal circular polarizations can be radiated by the same aperture, provided some constraints are met. These constraints do not allow application of traditional antenna pattern synthesis algorithms. First a mathematical model for linear antenna array for class of travelling-wave antenna is developed. A multi-objective evolutionary algorithm is applied to synthesize optimal excitation coefficients. The optimization objectives are chosen to enhance the quality of end (processed) SAR image. The result of the optimization is a Pareto curve yielding many possible non-dominated solutions. The relation between the chosen objectives is studied from the Pareto curve and a suitable solution is chosen. Next step, a computer model of the antenna panel is developed, simulated and a prototype unit fabricated. Measurements conducted show aperture efficiency of 50.1% and 49.2% at 9.65 GHz for right-hand-circularly-polarized and left-hand-circularly-polarized beams respectively. Low cross-polarization is achieved (axial-ratio < 1 dB) and the simulated range-ambiguity performance of the antenna shows the integrated range-ambiguity-to-signal-ratio less than -20 dB even for high-incidence angle imaging provided the (effective) pulse repetition frequency is less than 3 kHz. A

similar optimization procedure is applied for design of excitations of an array of antenna panels using the measured antenna pattern data from the prototype antenna panel. The result of this exercise is a novel design procedure involving multi-objective optimization to realize a compact travelling-wave SAR antenna.

To realize centralized feeding, a high-power RF source is required, which is possible by either using Traveling-Wave-Tube-Amplifiers (TWTAs) or Solid-State-Power-Amplifiers (SSPAs). Development of SSPAs is low-cost as compared to TWTAs, but they are poor in terms of the power output capability. The power output capacity can be increased by coherently combining output of several SSPAs. Different power combining techniques are discussed and a novel low-loss, compact power combiner is proposed. The proposed combiner is resonant in nature with cylindrical TM0m0 cavity. A novel way of directly interfacing the cavity and microstrip line of SSPA with no intermediate adapters (and hence mode-conversions) is presented. A prototype unit is manufactured and assembled, and its electrical characteristics measured. It exhibits insertion loss <0.77 dB (including measurement adapters) and active return power to an input power amplifier of -15 dB over bandwidth of 245 MHz near the designed center frequency.

This design of the dual-polarization traveling-wave antenna with centralized high-power RF source is proven to be compact and efficient. It also demonstrates the successful application of modern meta-heuristic multi-objective optimization techniques in antenna design and realization of a resonant cavity power-combiner directly interfaced to state of the art solid-state technology.