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COMPARATIVE ANALYSIS OF CONTROL ACCURACY IN ENERGY TRANSMISSION METHODS FOR SOLAR POWER SATELLITE

Abstract

Microwave beam Control accuracy is a major challenge in developing large-scale solar power satellites (SPS) and antenna system in the space environment. As a high-precision beam control system for large-scale wireless power transmission (WPT) systems of the SPS, we are developing a digital retrodirective method for an alternative to the existing software and hardware retrodirective methods. This method, based on digital signal processing (DSP), enhance time processing and phase synchronization through advanced precision and adaptability. Unlike its predecessors, it boasts a suite of features including frequency flexibility, dynamic amplitude tapering, sophisticated signal filtering, and minimized dependence on uplink power for direction finding, aiming independently signal processing for each antenna element. This enables real-time, accurate phase error corrections by conjugation and beam direction adjustments, significantly enhancing the resilience of SPS systems to physical deformations and environmental challenges.

A pivotal aspect of this new study is the comprehensive evaluation of the digital retrodirective method's control accuracy through rigorous experimentation operating at 5.8 GHz. Main lobe direction and side lobe level (MSLL) measurements, along with half-power beam width (HPBW), underpin the method's precision and potential for future applications. These experiments allow a meticulous comparison between the digital method and the conventional software retrodirective method performances in maintaining precise beam control under diverse and challenging space conditions. The findings evaluate the ability of each method to compensate phasing errors from antenna deformations but also its robustness in ensuring consistent and efficient power transmission.

This comparative analysis highlights the limitations and advantages of each approach, particularly in terms of processing latency, control accuracy, operational flexibility and sensitivity to environmental perturbations, thereby validating the most appropriate approach in critical SPS applications to ensure a reliable space power transmission. By overcoming challenges related to control accuracy and robustness against physical deformations and environmental disturbances, the practical implications of this research pave the way for the establishment a resilient and efficient large-scale power transmission system.