Numerical Simulation on Microwave Beam Pattern of SPS / Test Satellite in Consideration of Electrical and Structural Errors

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A Microwave Power Transmission (MPT) system is one of the essential technologies for Solar Power Station/Satellite (SPS). In resent studies, a unit-type SPS has been suggested. It consists of thousands of electrically-independent transmitting units, and each unit has a number of antenna elements. In terms of diversification of risk and ease of replacement against failures, the configuration of a unite-type SPS is superior to that of an all-in-one-type SPS

A beam controlling and focusing technique is a serious problem to develop an effective and harmless MPT system. A microwave beam from a SPS is sharply focused by the active phased array system. The microwave beam is desirable to be formed and controlled accurately, however, an actual beam pattern will become inferior to the ideal one because of two types of errors mainly: (1) electrical errors or phase errors of each antenna element, and (2) structural errors by distortion or perturbation of each SPS unit in space. These errors are supposed to cause an elevation of sidelobe levels and a generation of grating lobes. Accordingly, these harmful effects will not only dissipate microwave transmission energy outside of a receiving cite but also interfere in the other communication systems. The objective of the present study is to research how much electrical and structural errors affect the microwave beam patterns transmitted from a SPS with numerical simulation.

We have conducted one-dimensional beam pattern simulations on (a) unit-type test satellite case whose total size is the order of 10m, and (b) 1GW-class unit-type SPS case whose total size is a few kilometer. In the case (a) and (b), the satellite is on the Low Earth Orbit and on the Geostationary Orbit, respectively. In both cases, a transmitting frequency is 5.8GHz, antenna elements are arranged at even intervals in units, and each element has a 5-bit digital phase shifter. The electrical error introduced into simulations is random phase errors (normal distribution with standard deviation of 18 deg.) imposed on each antenna element. An arched-type structural error and a zigzag-type structural error, as shown in Fig.1, are considered as the structural errors in our simulation. As simulation results of the case (a), the ideal beam pattern is shown in Fig.2 and a beam pattern with a random phase error and an arched structural error is shown in Fig.3. It is evident from the results that these errors lead to increase of sidelobe levels and grating lobes. On the other hand, the mainlobe is hardly affected by these errors even though the test satellite has electrical and structural errors. We also simulate the case (b), and finally, we discuss about electrical and structural precision required for SPS.

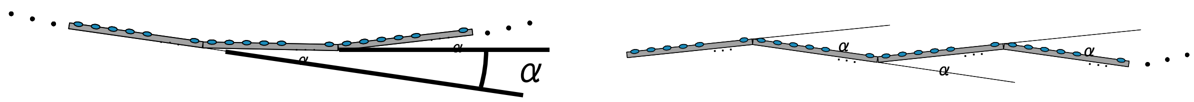

Fig.1 Structural errors (left: arched-type error, right: zigzag-type error)

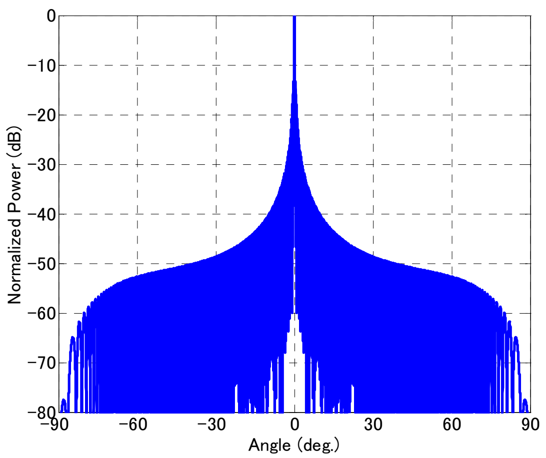

Fig.2 Ideal beam pattern in the test satellite case.

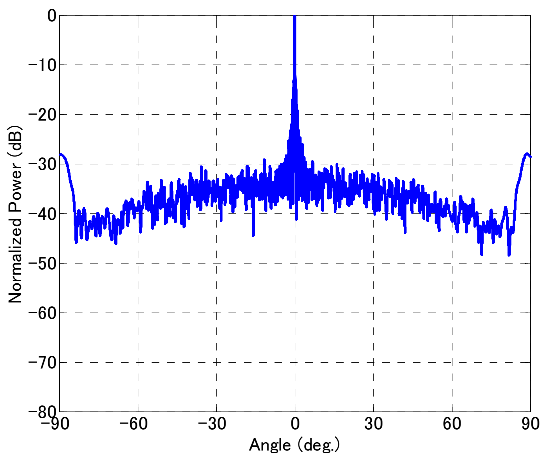

Fig.3 Beam pattern with a random phase error (normal distribution with standard deviation of 18 deg.) and an arched-type structural error (5 deg.) in the test satellite case.