A self-steering array and its application to phase synchronization of transmitter units and Solar Power Satellite

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POINT: Microwave power of Solar Power Satellite is radiated from a huge phased array antenna. A beam pattern of the microwave is controlled by phases of the antenna elements. Although their phase reference is important, it is difficult to make. We proposed a simple and unique method for the reference based on a revised self-steering array.

The concept of Solar Power Satellite (SPS) is very simple. It is a gigantic satellite designed as an electric power plant orbiting in the geostationary earth orbit. It consists of mainly three segments; a solar energy collector to convert the solar energy into DC electricity, DC-to-microwave converters, and a large antenna array to beam down the microwave power to the ground. The first solar collector can be either photovoltaic cells or solar thermal turbine. The second DC-to-microwave converters can be either a microwave tube system and/or semi-conductor system. It may be their combination. The third segment is a gigantic antenna array. The required accuracy of the beam control is less than 0.0005 degree.

SHARP (Stationary High Altitude Relay Platform) is a platform consisting of an aircraft powered by microwave energy sent from the ground. A unique self-steering array which automatically tracks the receiver (the spacecraft) by adjusting phase shifters based on its altitude and the reception intensity on the ground was used. We propose a revised system which does not require the altimeter and converges faster. When the distance between the transmitter and the receiver is large, the propagation delay makes the response time longer. We also propose a new method which overcomes this delay.

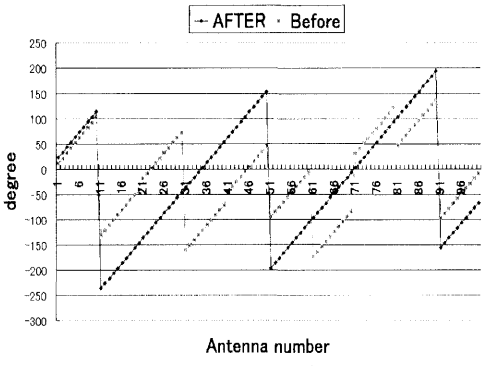

Fig. 1. Phases of array elements before and after the self-steering.

When a system is so large like SPS, the array would be composed of a lot of units. The system is too large to distribute a reference signal generated by a single reference oscillator. Although the beam steering is possible in each unit, a beam radiated from a unit could cancel that of another one depending on the phases of their reference signals. If independent oscillators are used, their requirement for the stability and accuracy could be quite strict. Although their frequency can be synchronized, it would be difficult to adjust the phases. The phase of each reference oscillator could be adjusted using the self-steering technique if each unit works under its own retrodirective system. Fig. 1 demonstrates an array of 10 units with 10 antenna elements. Before applying the present technique (pink line), phases of the array are adjusted only in each unit. After the self-steering (blue line), their phases are adjusted as a 10-unit system. The system works as a 100-element array.