Solar Power Station/Satellite (SPS) with Phase Controlled Magnetrons

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Since the first proposal of a Solar Power Station in Space in 1968, many different types of the SPS have been proposed. The SPS reference system (NASA/DOE; USA), the SPS2000 (ISAS; Japan), the Sun Tower (NASA; USA)[1] and Recent Japanese Models (NASDA[2]; METI[3]; Japan) are among them. Some of them are designed based on a microwave power transmitter with microwave tubes. The electronic tubes such as Klystron or magnetron have high efficiency (>70%) and high power output (over kW). However, the microwave power density at a transmitting antenna element of the SPS is too high ranging from several tens watts/element to a few hundred watts/element. Therefore, we must use a system providing the power from one electronic tube to a single sub-array unit or to insert a power divider with phase shifters between the power device and each antenna element. We refer to this system as a PD-PS system. The sub-array system suffers from little power loss but generates grating lobes when power beam is electronically swung. As the microwave power from the SPS is huge, we must lower the grating lobe level to satisfy the requirement for the compatibility with the existing communication system. On the other hand, the PD-PS system generates very little grating lobes, but its power loss is not negligible.

The other design of the microwave power transmitter is to use semi-conductor amplifiers. In this case, we could achieve a system with very small or no grating lobes. However, the efficiency of the semi-conductor amplifier is still below 40% [4]and still much more expensive compared with the microwave tubes. Either system, therefore, does not attain sufficiently high DC-RF conversion efficiency. The higher the efficiency, the less launching weight and size can be attained. In this paper, we show a new concept of a microwave transmitter with phase controlled magnetrons (PCM)[5]. The PCM is developed at Kyoto University. The PCM is composed of a PLL anode-current controller with a magnetron as amplifier. The microwave output of the PCM is smaller than that of a Klystron adopted in the NASA-SPS reference system. The RF-DC conversion efficiency of the PCM is higher than that of a semi-conductor amplifier. In parallel to the development of the PCM, we develop a low loss power divider and a low loss phase shifter. Combining the PCM with a low-loss PD-PS system, a small sub-unit with the PCM with high efficiency will be achieved. We will discuss and show our experimental results of the PCM system in the presentation. Also we will discuss another new system with a parabolic antenna sub-array system.

REFERENCES

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