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Space-Based Solar Power Architectures / Space & Energy Concepts (1)

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CHALLENGES AND SOME POSSIBLE SOLUTIONS FOR SPACE SOLAR POWER STATION DESIGN

Abstract

Space solar power station (SSPS) has been proposed to collect sunlight in space and transmit it to ground for terrestrial use with wireless power transmission (WPT), which may be one of the best ways to satisfy the energy requirement of human beings. Typical SSPS consists of three main parts: light-collecting system, energy converting/transmitting system and receiving/converting system. Among them, the light-collecting and the energy converting/transmitting system work in the geostationary earth orbit (GEO), which need to be launched into space and assembled in orbit. For this reason, their mass, size and complexity determine the cost and feasibility of SSPS to a large extent. However, for the available SSPS design with a power of gigawatt(GW), there exists a huge structure with a mass of thousands of tons and a complex control system for sun tracking in the light-collecting system. Furthermore, to achieve a narrow beam and accurate beam-pointing, the giant phased array antenna, with an aperture of several hundred meters and a mass of nearly ten thousand tons, was proposed in the energy converting/transmitting system, leading to great technical challenges and a very high cost. Therefore, some new solutions need to be studied to rise to the challenges. One solution is to develop novel concentrator based on zero-index metamaterial(ZIM) or metasurfaces. Sunlight can be bent towards the normal and condensed with ZIM or metasurfaces. Therefore, neither the solar tracking system for concentrator nor massive heliostats is necessary, resulting in simplification of the concentrating mechanisms. The mass can be reduced and the structure and control system can be simplified dramatically. Another solution is to develop transmitting antenna based on lens and thin-film reflector. It is possible to generate a very narrow beam with small antenna aperture size by combination of the lens and thin-film reflector, leading to a small and light-weighted transmitting antenna. In addition, high-power maser technology has great potential in SSPS. With high-power maser technology, a high-intensity, good-direction and single-frequency microwave beam can be obtained without huge transmitting antenna, which will improve the engineering feasibility of SSPS significantly.