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LAYERED DIELECTRIC STRUCTURE FOR MICROWAVE WIRELESS POWER TRANSMISSION SYSTEMS

Wireless power transmission (WPT) is a rapidly developing science and technology area in which intensive research is being carried out now. Various WPT technologies are being developed, WPT system projects of numerous classes and functionalities are being implemented, new areas of their application are being discussed, and numerous theoretical and experimental studies are being carried out. The references devoted to the WPT research indicate their increasing influence on the development of global energy processes. Nevertheless, despite significant advances in this area, many problems are still in the early stages of research [1, p. 1]. Currently, several methods of WPT can be distinguished: inductive, microwave, laser, and energy harvested from the surrounding electromagnetic field. The concept of wireless energy transmission via microwaves was practically implemented in the 1960s due to the radar technology development, the exploration of the microwave frequency range, and the invention of rectennas by W. Brown. His work resulted in the creation of a new class of energy systems – microwave WPT systems. Such systems consist of a transmitting subsystem, whose task is to convert the energy from the primary source into focused EM waves, and a receiving subsystem in the form of rectennas. The purpose of rectennas is to receive and convert the focused EM waves into direct current, which is supplied to the energy consumer then [2, p. 116].

Higher harmonics are emitted due to the presence of nonlinear elements in the receiving subsystem of microwave WPT. From a practical point of view, it is important to reflect the radiation at the second harmonic of energy basic transmission frequency (EBTF) backward into the device for converting an electromagnetic wave into direct current. For this purpose, a layered dielectric structure was considered in a rectangular waveguide, which was supposed to reflect radiation at the frequency of the second harmonic of EBTF and to match in a wide frequency pass band around the EBTF. The layered dielectric structure consisted of three parts: matching, Bragg, and reverse-matching ones. The first and third parts of the layered dielectric structure were comprised of matching dielectric layers at the EBTF. This structure was placed in a rectangular waveguide with a cross-section of 23mm×10mm and filled with air. It was taken into account that the angle of the electromagnetic wave incidence on the layered structure in the waveguide depends on the wavelength and is determined by the Brillouin concept for the fundamental wave H_{10} according to the following formula:

$$\theta_i = \operatorname{asin}\left(\frac{\lambda}{2a}\right) \tag{1}$$

The reflectance of the structure was found using the known expression:

$$R(\mathrm{f}) = \frac{R_{01}+R_{12}\exp\left(-i\cdot 2\varphi\right)}{1+R_{01}R_{12}\exp\left(-i\cdot 2\varphi\right)}, \tag{2}$$

where R_{01} and R_{12} are Fresnel reflectance complex coefficients.

Thus, the dependence of the reflectance versus frequency was constructed for the given structure. This layered dielectric structure allows achieving the width of the pass band of 2.2 GHz at EBTF and the width of the block band approximately 2 GHz at a frequency of the second harmonic. The highest value of the reflectance was obtained at the second harmonic frequency, which was equal to 0.98.

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MAJOR GLOBAL SATELLITE NAVIGATION SYSTEMS, ROLE AND CHALLENGES

Satellite navigation systems are complex electronic and technical systems consisting of a set of ground and space equipment and designed for positioning in space and time, as well as determining of movement parameters for land, water and air objects [3, p 125].

The role of positioning systems in the modern world is difficult to overestimate. A failure or absence of a navigation signal from the usual GPS can lead to chaos in the operation of air and sea transportation, consumer goods delivery services, and