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ROZPRAWA DOKTORSKA

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Wybrane zagadnienia układów bezprzewodowego
przesyłu energii elektrycznej
z silnym sprzężeniem magnetycznym

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SELECTED ISSUES OF ELECTRIC POWER TRANSMISSION SYSTEMS WITH STRONG MAGNETIC COUPLING

Abstract

The dissertation discusses the basic problems of wireless electric energy transmission systems through inductive power transfer (IPT) with strong magnetic coupling. Strong magnetic coupling means a magnetic coupling factor greater than 0.7. Additionally, a desirable feature of the described systems is the stiffness of the output voltage, understood as small changes in the output voltage with changes with the system load (assuming a constant supply voltage). Such systems are widely used in power supply systems for mobile handheld devices (e.g. toothbrushes, cell phones) and higher power devices, e.g. electric cars.

A review of the literature showed that there are no studies on the design methods of IPT systems (without feedback) providing voltage stiffness discussing the issues in a comprehensive manner. Existing publications neither show the full spectrum of solutions nor discuss system efficiency problems. This allowed the formulation of the thesis: It is possible to construct simple wireless electric energy transmission systems with strong magnetic coupling, which, without the use of feedback, ensure considerable stiffness of the output voltage.

The thesis was proved by applying two methods of system modeling: symbolic and numerical. The first method allows to explain the idea of the proposed solution in a simple way and enables the initial selection of optimal parameters of the system due to the minimization of power losses. The symbolic method shows that for the presented IPT systems (series-series systems) it is possible to separate two independent voltage ratios: compensating and transformer. The output voltage depends on the product of these ratios. This leads to the problem of optimizing the efficiency of the system, which was solved analytically.

Numerical method allows to better simulate the operation of the system with power electronic converters - a bridge inverter and a bridge rectifier. Contrary to the symbolic method, the solutions do not assume sinusoidal voltages and currents waveforms. The method allows to calculate systems with conduction states (SP) and non-conductive states (SNP) of rectifier. This has a significant impact on the way the calculations are performed.

The analysis of the results and the conclusions drawn allowed to create a method of designing IPT systems and a prototype. The prototype was tested for the goals of the dissertation. Then the results were compared with those obtained with the symbolic and numerical methods.

The dissertation thesis has been proven and the main and detailed goals have been achieved. The prototype turned out to maintain the voltage stiffness within a certain range, and its efficiency is consistent with that presented in the models.