ABSTRACT OF THE DISSERTATION

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***Resonant cascades of magnetically coupled coils for wireless electrical energy transfer***

The dissertation describes an analysis of wireless electrical energy transfer to relatively large distances by means of magnetically coupled coils. The analysis concerned the properties and parameters of resonant cascades of magnetically coupled coils, models of the wireless electrical energy transfer system and their experimental verification.

In the part of the dissertation devoted to the analysis of properties of resonant cascades of magnetically coupled coils, the focus was on determining the most favorable parameters of the coils. They should ensure that the values of magnetic coupling and quality factor are as high as possible, which has a direct impact on the efficiency of the cascade. It was established that the maximum of the product $kQ$, which determines the efficiency of the cascade, depends on the coefficient of filling of the windings, the relative distance between the coils and the system frequency. The preferred fill factor value of the coil is within 0.5...0.8.

The simplified and complex models were developed for the purposes of analysis of properties of wireless electrical energy transfer systems with resonant cascades of magnetically coupled coils. In both cases, matrix absolute models of the system were developed, which after introducing appropriate reference values were changed into relative models. The simplified model was obtained using the symbolic method, changing wireless electrical energy transfer system to an AC/AC circuit. The possibility of higher harmonics of voltages and currents is completely ignored in this case. The source of higher harmonics in the wireless electrical energy transfer system is the inverter at the cascade input and the rectifier at its output. The complex model considers the case in which the source of higher harmonics is only the bridge rectifier connected to the output of the cascade. When developing the complex model, the principle of superposition of the first and higher harmonics was used.

The general algorithm for designing a wireless electrical energy transfer system was presented. This algorithm allows to determine generalized design characteristics. They enable wireless electrical energy transfer system design without the need for numerical optimization. Parameters of the cascade for given design assumptions are read from relative characteristics and appropriately converted, taking into account reference values.

A laboratory system for wireless electrical energy transfer with a resonant cascade of magnetically coupled coils was designed, constructed and tested. The individual components of the laboratory system have been described in detail and the results of laboratory tests have been presented, which served to verify positively the generalized method of designing such systems. The designed and constructed system can be characterized as follows: 16 flat coils with an outer diameter of 15 cm, transfer distance 1 m, frequency 350 kHz, output power 100 W, efficiency 80.31(36)%. The efficiency of the cascade itself was 85.3%.

The concept of a system for charging of the electric energy storage (e.g. capacitor or supercapacitor banks) is presented. A system for wireless electrical energy transfer with a resonant cascade of magnetically coupled coils was designed, constructed and tested. The laboratory system included an additional SEPIC converter with a measurement and control system, whose task was to stabilize the cascade load. The efficiency of the system was 74.70(34)%.