A resonant-mode power supply with a multi-winding inductor

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Resonant Power Converter

Subject of the invention is a resonant-mode power supply with a multi-winding inductor based on a LLC type series resonant circuit with an energy recirculation system (ERC1), used to limit the quality factor of the resonant circuit, working in DE class and dedicated for applications in medium and high power systems - from hundreds of watts to more than dozen/tens of kW).

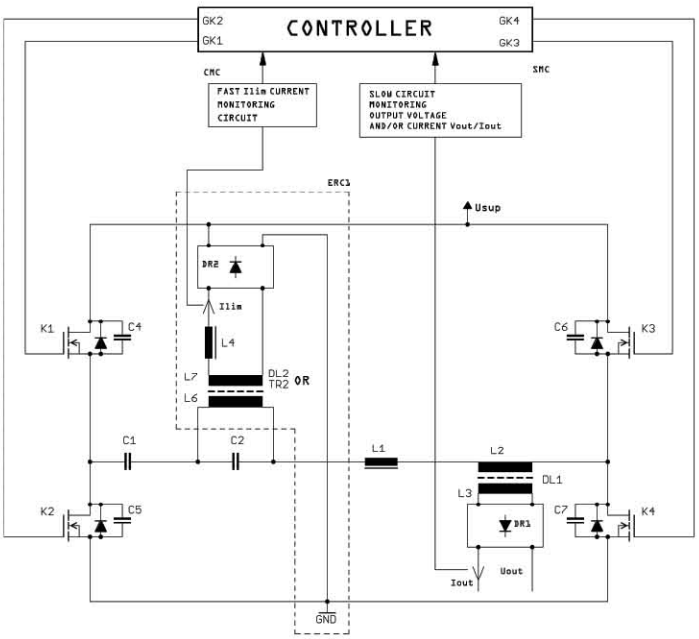


Fig. 1. The diagram of the converter with LLC series resonant circuit working in DE class with a resonant circuit energy recirculation system (ERC1) conected in parallel to the resonant capacitor C2.

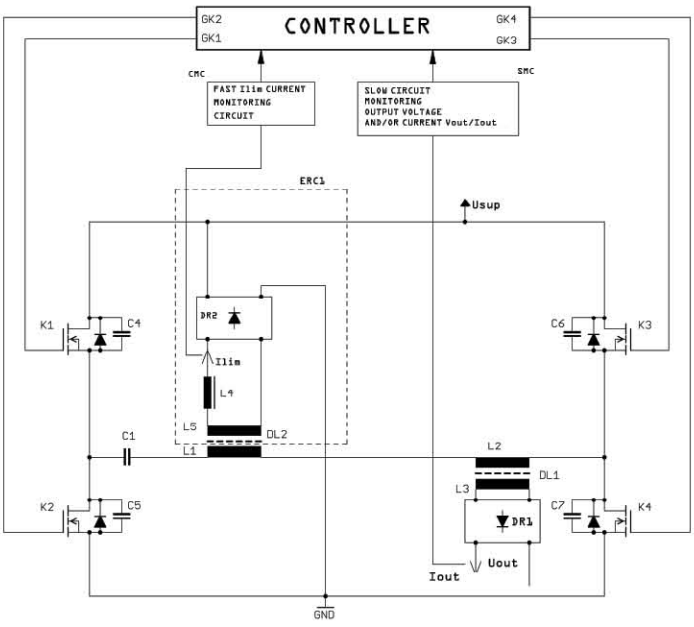


Fig. 2. The diagram of the converter with series LLC resonant circuit working in DE class with resonant circuit energy recirculation system (ERC1) connected to resonant inductor L1 via strong coupling with inductor L5.

Figures 1 and 2 show diagrams of the full bridge converter with an integrated quality factor limiter system (ERC1). The converter includes the K1-K4 switches forming a full bridge. The diagonal of the bridge incorporates serial resonant circuit, composed of C1 (or C1 and C2) capacitor and a series connection of inductor L1 and primary inductance (L2) of the multi-winding inductor DL1, through which the load is connected to the power-supply.

In the simplest, yet relatively efficient version, stabilization of the output voltage or current is done by adjusting the switching frequency, with a constant dead time set large enough to achieve the effect of soft switching of K1-K4 during output short circuit, that is typical for the DE class.
Distinguishing features of the presented topology:

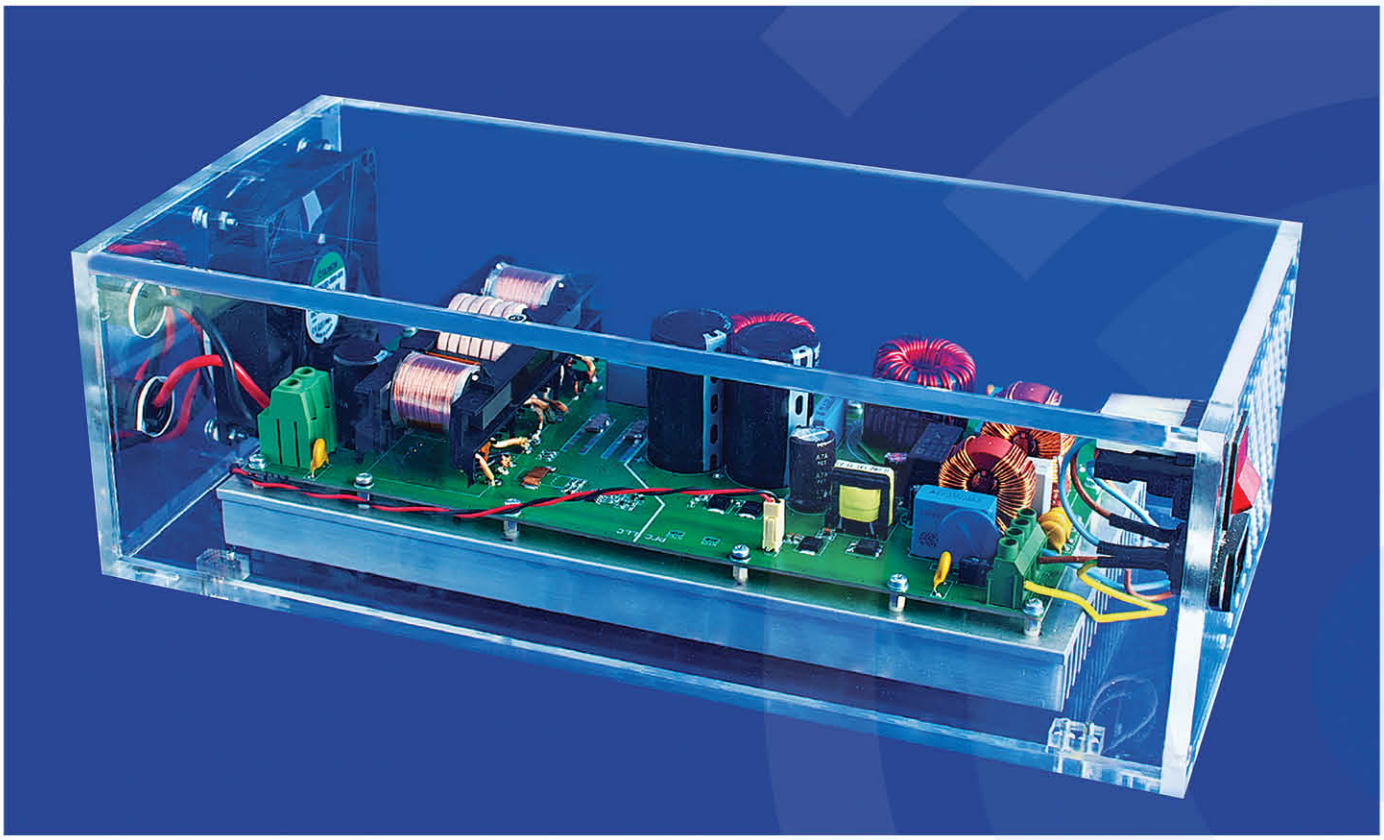
- quality factor limiters which have a task of recirculating, almost without losses, excess energy that can occur in resonant circuit in transient states back to the power source, and thus reduce the quality factor of the resonant circuit, which allows in turn to secure the structure against overvoltages and overcurrents;
- current excess detector in quality factor limiter allowing very fast response to decrease power delivered to the inverter from power source, detection of undesirable region of operation and reduction of the power circulating between the power supply and the resonant circuit;
- output transformer formed as a multi-winding inductor, having an air gap inside it's magnetic circuit, and the inductance of primary winding being a part of the resulting inductance of the series resonant circuit. Such design of power system and load connection allows to maintain uninterrupted current flow through the series resonant circuit at sufficiently high level, also under no-load condition, which in turn allows to increase the dynamic of response to sudden changes in load.
- possibility of reducing power losses, dimensions and weight of the converter by adopting Integrated Induction Element utilizing the phenomenon of superposition of magnetic flux in fragments of an integrated magnetic circuit.

Presented solution has the following major advantages:

- scalability of the solution, allowing construction of power supply systems with output power from hundreds of watts to over a dozen/tens of kilowatts;
- monitoring di/dt current change rate in resonant and commutation circuit;
- monitoring overvoltages and overcurrents in resonant and commutation circuit;
- possibility of using soft switching ZVS technology;
- possibility of operation in a wide frequency range (a couple of kHz to hundreds of kHz);
- current source nature of output circuit;

- possibility of stabilizing output voltage in the full range of load changes;
- possibility of obtaining high efficiencies;
- possibility of operating with continuous current in resonant circuit irrespective of load;
- sinusoidal waves of currents in power circuit;
- low emission of conducted and radiated interferences, resulting in reduced cost of meeting EMC requirements.

The described solution has a good chance of meeting strict requirements related to high performance medium and high power resonant energy conversion systems, in particular in the area of professional applications, with efficiency exceeding 94%. Flexibility of the solution will also allow its use in price-sensitive products.



Technology offer

The resonant-mode power supply with a multi-winding inductor are subject to patent protection. AGH University of Science and Technology in Krakow offers :

- a non-exclusive license for use of the technology in selected fields of application
- adaptation of the technology to customer's needs

All interested parties may contact:

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