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A compact 210-kV, 10-kJ/s capacitor charger for industrial applications

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A compact 210-kV, 10-kJ/s heavy-duty capacitor charger is described. One possible application is solids fragmentation. The charger has universal three-phase input. Pulse repetition rate (PRR) can be from single shot to 250 Hz, depending on the storage capacitance. Energy dosing (ED) topology [1] was chosen. It facilitates high wall-plug efficiency of typically 92% at switching frequency of up to 55 kHz while using low-cost standard IGBTs with low static losses.

Minimizing energy stored in the multiplier, Ems, was one of the major focuses of the development because Ems does not reach the load. It is dissipated mostly in the arc-limiter circuitry. Hence, the multiplier is center-fed, which minimizes Ems.

Circuit simulations show zero-current switching at variable frequency during the charge, which was also evidenced by experiments. A reduction of peak power drawn from the primary source compared to conventional series-resonant chargers is observed.

Another main design challenge was insulation design. Criteria of choice of permissible electric stress for complex voltage waveshapes are given. Insulation design was guided by subsystems tests and assisted by electrostatic field analyses performed in both 2D and 3D. Field plots of the HV transformer as the most stressed part are shown. Magnetic field simulations and eddy current 3D analyses helped in magnetics design.

Multiple tests were executed. Custom test accessories, e.g., a precision, high-impedance, fast HV divider were developed. The charger was successfully tested with stored energy of up to 550 J at discharge via a compact custom-designed spark gap at PRR up to 50 Hz (in bursts).

The charger was tested also at a customer site. Future work will focus on customization for different applications and collecting field data.

[1] A. Pokryvailo et al., "High Power, High Performance, Low Cost Capacitor Charger Concept and Implementation", IEEE Transactions on Plasma Science, Vol. 38, No. 10, 2010.

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