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Compact Power Supply with Integrated Energy Storage and Recovery Capabilities for Arbitrary Currents up to 2 kA

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PROTO-SPHERA can be considered as the first tokamak with a simply connected configuration, namely without external components (as the central coil) inside the plasma volume. The tokamak-like shape is obtained by the self-organization of a plasma arc (pinch) in a cylindrical vacuum vessel, resulting in a minimal aspect ratio with a high confinement efficiency.
The first PROTO-SPHERA experiments suggested to introduce further external coils to adjust the internal magnetic field. Even though the coil power supply (PS) would require currents up to 2 kA with peak powers higher than 400 kW, it operates with a low duty cycle (≈2 s every 600 s) and with a limited net energy.
This is a typical situation in nuclear fusion and plasma facilities: the PSs are oversized to sustain short peak demands. On the other hand, the new PS developed for PROTO-SPHERA exploits an integrated energy storage system (ESS) to deliver all the output power, requiring a very low (and tuneable according to the situation) input power (<1 kW) and only when the other PSs are not operating. In some cases, a portion of the injected power can be recovered in the ESS. The voltage available for the ramps is ±200 V, but a different compromise among voltages, currents and times can be obtained by rearranging the ESS configuration (mainly based on supercapacitors).
The final scope of the research is to develop standard and general-purpose PS and ESS modules to achieve higher currents and voltages without significant (compared with the output) demands from the power distribution systems and from the national grid. The modular topology would simplify the PS maintenance and would reduce the overall costs.
The possibility to extend this approach to many PSs of a large facility, as a tokamak, will be discussed showing interesting prospects and open issues.

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