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Cascaded Multilevel Converter with Floating Capacitors for a small tokamak, PHiX

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PHiX (Plasma with Helical field initiative eXperiments) is a small tokamak to research MHD phenomena such as restraint of elongated plasma instability and protection of tokamak devices from disruption. The device has 16 toroidal field coils (TF coils) and 10 poloidal field coils (PF coils) magnets. We found that we must drive these coils for more than 5-ms and the response of PF coil current must be less than 1-ms to have clear experiment and control unstable elongated plasma. That is because MHD time scale or the time constant of plasma movement is nearly 1-ms in our device. It is desirable that the TF coil current keep constant during experiments to make it easy to control plasma current, position and shape. To achieve this requirement, we developed a 55kW inverter-driven flywheel motor-generator. Advantages of the MG are comparably-long duration, quick power response, and easy implementation of power control compared with conventional capacitor-type power supply. The duration of the current flat-top was extended to 1-s, which is much longer than those of conventional small devices. To control plasma position and shape, PF coil currents must follow the command value within 1-ms and the power supplies must be able to output enough voltage. We manufactured 900-kVA PF coil power supply system that can excite 10 individual coils. To realize enough voltage, we designed the circuits to reconstruct them to cascaded H-bridge multilevel inverters with floating capacitors. These output are connected in series and capacitors are connected to DC-links of some of H-Bridges. This idea enables to heighten output voltages without extra transformers. In our presentation, we report the details of power supplies such as construction, circuits and control and the tokamak experimental progress and result of PHiX.

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