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Application of the voltage control mode of second-generation EAST active feedback power supply

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The ability of magnetic confinement to plasma can be improved by elongating plasma cross-section in EAST (Experimental Advanced Superconducting Tokamak). But elongated plasma has vertical displacement instability, without control, plasma will dash against wall of vacuum vessel and disrupt, that will cause failure of plasma discharge. So feedback control system is needed to restrain plasma vertical displacement. PCS (Plasma Control System) detects the vertical displacement of the plasma and calculates the value of signal sent to power supply, the signal is real-timely tracked and linearly amplified to generate a fast-changing magnetic field, which will suppress the vertically unstable displacement of the plasma.

The analog control was adopted in the first-generation active feedback power supply, which worked in current tracking mode. The conventional proportional regulator which guarantees satisfactory control accuracy of the output current was adopted.

DSP (Digital Signal Processing) was adopted as the main control chip. To achieve the maximum current's rising rate, second-generation EAST plasma vertical displacement active feedback power supply applies voltage control mode while retaining the first-generation current tracking mode. Its average output voltage value is linear to given voltage signal. For a given voltage signal of 10V, the power supply outputs 1600V, and -1600V corresponds -10V. Compared with current mode, voltage mode achieves a significant increase in rising rate of load current. However PCS cannot be fully counted on to detect the real-time load current and change the polarity of the given signal before the current exceeding its limitation, so power supply system itself must possess perfect over-current protection function.

The driving signal is blocked when the output current reaches the protection threshold value and resumed after falling below a certain set value. In this status, the stored energy within the load coil inductance can only be released through the inverse parallel diode of the IGBT (Insulated Gate Bipolar Transistor) to storage capacitors on DC side, which will lead to continuous increase of DC voltage. When the power supply outputs high voltage, the accompanied frequent over-current protection will return the power to DC side, which leads to over-voltage protection. To solve this problem, the current limiting control mode is adopted. The current limiting mode will stay till the polarity of input voltage signal changes.

In 2014 EAST experiment, voltage mode was applied to plasma vertically unstable displacement by the second-generation active feedback power supply. In 52444th experiment, active feedback system exhibits great control ability to vertical displacement of plasma. Even plasma reaches vertical displacement of 4.6cm and growth rate is 530/s, the active feedback system is still able to pull it back to equilibrium position, while the first-generation active feedback power supply can only deal with 1.9cm of plasma vertical displacement and growth rate is 150/s at most.

Through exploration of voltage mode, combination of voltage open loop control and current limiting control is present and the control effect was verified by EAST experiment, which will provide new idea to control vertical displacement of the plasma.

Eligible for student paper award?

No

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