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Design & Development of High Voltage Power Suppliy for Negative Ion Source

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Neutral beam injection(NBI) is an essential plasma heating tool for the China Fusion Engineering Test Reactor(CFETR),that is under engineering conceptual design.The CFETR NBI of energy higher than 500keV is needed. Because of neutralization efficiency of negative ions is higher than that of postive ions under the high energy,the negative ion source is required for NBI,which ask for higher voltage than positive ion.High voltage power supplies(HVPS) is very important power supply for Neutral beam injection (NBI) of fusion experimental device.To simplify the system structure and improve the high accuracy of out voltage, the quantity of the switch power supply(SPS) modules should be as little as possible.Therefore, a HVPS of moderate voltage and number be needed.Then an HVPS for the negative ions NBI is proposed,which must be designed by having a few different voltage classes of SPS in series by link.Meanwhile, the control of SPS of negative ions NBI becomes more complicated and difficult because of the power supply has many different voltage rating.
A set of HVPS with PSM topology at 16kV /20 A has been designed and successfully tested at Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP).The power supply has the characteristics of high stability, fast dynamics, short protective time and low stored energy. This power supply consists of 19 modules of 800V and 8 modules of 100V. 27 series-connected SPS modules are fed from multisecondary transformers.Insulated-gate bipolar transistor (IGBT) is used as the output switch to improve the HVPS dynamic performance.HVPS output voltage is adjusted by the control system.To ensure normal HVPS operation and fulfill the requirements of ion sources, the control system has characteristics of setting voltage preset value and different rise or fall times of voltage of HVPS,blockading the voltage output of the HVPS in case of faults,etc.To reduce voltage overshoot by the simulation,a proportional (P) controller is selected to control the out voltage of HVPS. The feedback control system runs on digital signal processor (DSP) and field programmable gate array(FPGA).To isolate the high potential and avoid the electromagnetic interference,all the control circuit interfaces are through fiber optic cables for HV isolation.
Dummy load made of resistance is necessary to observe power system performance. The rise time of out voltage can be set from to .Solving the balance between the rise voltage overshoot and rise time,the method is that SPS modules be sequentially turned-on according to the 90% of the value of preset voltage at the setting rise time,and then later other modules be opened step by step atinterval until reaching the preset value of output voltage via close-loop feedback control.The test results of dummy load that HVPS complies with the requirements of negative ion NBI Extraction.It is planned to assemble the negative ion source and the HVPS, then start the experiment of negative ion extraction in the next stage.This power supply will be extended at more voltage ratings or higher voltage ratings and applied to an accelerator system for negative ion sources NBI HVPS in the future.

Eligible for student paper award?

Yes

Author: HUANG, Meichu (Institute of Plasma Physics, Chinese Academy of Sciences)

Co-authors: JIANG, Caichao (Institute of Plasma Physics, Chinese Academy of Sciences); HU, Chundong (Institute of Plasma Physics, Chinese Academy of Sciences); ZHAO, Yuanzhe (Institute of Plasma Physics, Chinese

Academy of Sciences)

Presenter: HUANG, Meichu (Institute of Plasma Physics, Chinese Academy of Sciences)

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