Solid-State High Voltage Modulator and Its Application to RF Source High Voltage Power Supplies

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ABSTRACT

A solid-state high voltage modulator is described in which series-connected insulated-gate bipolar transistors (IGBTs) are switched at a fixed frequency by a pulse width modulation (PWM) regulator, that adjusts the pulse width to control the voltage out of an inductor-capacitor filter network. General Atomics proposed the HV power supply (HVPS) topology of multiple IGBT modulators connected to a common HVdc source for the large number of 1 MW klystrons in the linear accelerator of the Accelerator Production of Tritium project. The switching of 24 IGBTs to obtain 20 kVdc at 20 A for short pulses was successfully demonstrated. This effort was incorporated into the design of a −70 kV, 80 A, IGBT modulator, and in a short-pulse test 12 IGBTs regulated -5 kV at 50 A under PWM control. These two tests confirm the practicality of solid-state IGBT modulators to regulate high voltage at reasonable currents.

Tokamaks such as ITER require large rf heating and current drive systems with multiple rf sources. A HVPS topology is presented that readily adapts to the three rf heating systems on ITER. To take advantage of the known economy of scale for power conversion equipment, a single HVdc source feeds multiple rf sources. The large power conversion equipment, which is located outside, converts the incoming utility line voltage directly to the HVdc needed for the class of rf sources connected to it, to further reduce cost. The HVdc feeds a set of IGBT modulators, one for each rf source, to independently control the voltage applied to each source, maximizing operational flexibility. Only the modulators are indoors, close to the rf sources, minimizing the use of costly near-tokamak floor space.

Keywords: high voltage power supply, RF power systems, ITER RF systems, plasma heating and current drive