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Design and Development of 500 kV, 100 mA DC High Voltage Power Supply for Particle Accelerators at IPR

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At IPR Neutral Beam Injection (NBI) facility to heat and drive the plasma current in Tokamak is been built by accelerating the positive / negative ion beam of energy around 100 keV. Under the current R&D plan the projection is to develop the technology for future Mega Volt range DC Power Source facility to accelerate ion beam of energy to the tune of 1 MeV and power of the order of few MW. To meet this objective a compact 500 kV, 100 mA DC upgradable to 1000 kV Power supply is being designed and developed as a first step. This power supply shall also be used for several other applications within IPR related to particle accelerator.
The 500 kV, 100 mA, 50 kW DC particle accelerator power supply is being designed using a symmetrical Cockcroft-Walton (CW) voltage multiplier topology owing to its design simplicity and economical construction. Other advantages of such cascade generators are: (a) low voltage rating of components, (b) balanced voltage w.r.t. ground, (c) gradual build-up of voltage, and (d) modular construction. The use of a high frequency power source gives an added advantage of low stored energy, less ripple, better regulation and faster response. A 415 V, 50 Hz 3-phase AC input source is converted into single phase high frequency (i.e. 20 kHz) source using IGBT based full H bridge inverter power supply rated for 100 kVA, 400 V (rms). The high frequency power supply charges the symmetrical CW voltage multiplier through a high voltage high frequency (HVHF) step-up center-tap ferrite core transformer rated for 80 kVA, 400 V / 25 kV −0 −25 kV (rms). The output voltage and current of the voltage multiplier unit are controlled by controlling the output voltage of the front end inverter operating in close loop control.
This paper will present the design and simulation results of 500 kV, 100 mA DC Power Supply modeled in MATLAB Simscape toolbox. The paper will explain the optimization / sensitivity study performed in selecting and sizing of various active / passive components of CW voltage multiplier, inverter and step-up transformer taking into account the possible operational difficulties and future expansion. Both steady state and transient study results will be explained. This paper will briefly cover the engineering assembly design aspects of voltage multiplier unit in general and of a 250 kV prototype voltage multiplier developed.

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