A.12: Development of 150 kVA, 430 Hz power source for high voltage generator of 2.5 MeV dc accelerator

A 2.5 MeV DC accelerator, based on ELV-type electron accelerators, is being developed at RRCAT. The scheme for generating high voltage in this accelerator is based on air-core, multi-secondary step-up transformer. Each secondary has voltage doubler rectifier and filter, the outputs of which are connected in series to generate the high voltage. As opposed to the conventional transformer, the air-core transformer has large leakage inductance (L_s) and small magnetizing inductance (L_m). The air-core transformer has poor regulation and draws a large reactive power from the source feeding the primary winding. A special ac power source, therefore, needed to feed the primary windings of the air-core transformer, that has in-built suitable compensation scheme must be employed to minimize the undesirable effects of the associated characteristic inductances.A compensation scheme that results into near-unity power factor operation under all loading conditions and nearly load independent output voltage was proposed, analyzed and implemented.

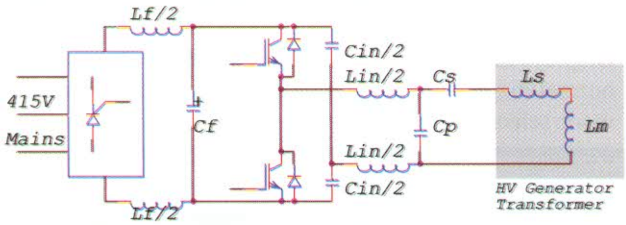


Fig. A.12.1: Schematic of the power source

As shown in Fig. A.12.1, three-phase six-pulse SCR controlled rectifier with LC filter is used to convert three-phase ac mains into controlled and regulated dc voltage using phase angle control. It is followed by a half-bridge square-wave inverter using IGBTs that operates in a free-running mode and converts dc to square-wave ac voltage of required frequency, which is typically 430 Hz. The L_s and L_m are used as the part of the compensation networks that additionally contains water-cooled capacitor banks (C_s, C_p and C_{in}) and resonant inductor, L_{in}. The power supply has been housed in two adjacent cabinets, as shown in Fig. A.12.2. A 0.8 m X 1.3 m X 32 U cabinet houses the mains circuit breakers, 6-pulse controlled rectifier with its filter, IGBT half-bridge and the control rack and a 1.3 m X 1.3 m X 32 U cabinet houses the components of compensation network. Laminated busbar connection has been used for connection of IGBT bridge with dc-link capacitors to reduce stray inductance, thereby significantly improving the switching performance of the IGBTs. Accessibility of the components for easy assembly and maintenance has been the major criteria in component layout, consistent with electrical requirements. CTs and PTs are provided at key locations to monitor the currents and voltages. Calibrated replica of important currents and voltages in the circuit are available for on-line monitoring for diagnostics and their rms values are displayed on a digital panel meter along with other parameters. Two external interlocks with potential-free normally-closed contacts have been provided to shut-down the unit in case of external faults.

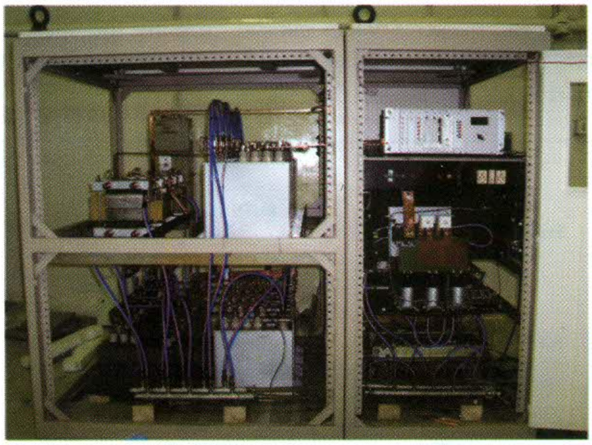
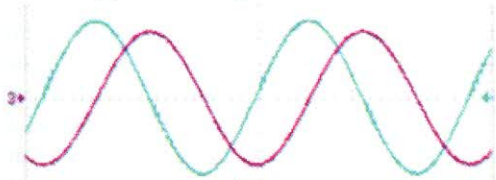
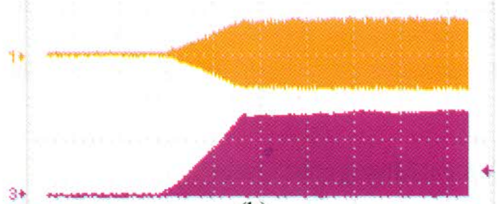


Fig. A.12.2: Photograph of the power source

The unit has been tested extensively on a dummy inductive load as well with the primary windings of high voltage generator. Fig. A.12.3(a) shows the waveforms of output voltage (cyan, 200V/div) and output current (pink, 200A/div), with time scale of 500 µs/div, showing operation at 250V, 220A rms. Fig. A.12.3(b) shows the waveforms of output voltage (yellow, 200 V/div) and voltage across one of the IGBTs (pink, 50 V/div) during start-up condition with time scale of 10 s/div, showing gradual increase in the output and dc link voltage without significant overshoot.



(a)



(b)

Fig. A.12.3: Experimental results showing (a) output voltage and current in steady state, and, (b) output voltage and voltage across IGBT during start-up.

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