L.5: Development of 35kV, 150mA, constant current, capacitor charging power supply for pulsed xenon chloride excimer laser

A constant current capacitor charging power supply was designed and developed to source the thyratron driven MPC based, pulsed power supply of excimer laser at Laser Systems Engineering Division of RRCAT. It was an IGBT based, variable frequency, multi-mode, half- bridge, inductor-inductor-capacitor (LLC) type resonant power supply, as shown in fig.L.5.1, A 50nF/40kV capacitor is charged at a repetition rate of 100Hz using the power supply. It can operate with a wide input voltage range of 415V ±15% 3ph, AC, with DC-DC efficiency better than 92% at 35kV and 3.5kW output. The capacitor charging requires operation over a wide range of load conditions varying from nearly short circuit to nearly open circuit. This kind of performance can be best achieved by supplying a constant charging current through a multimode controller. This controller will work in burst mode when there is no load or light load. The variable switching frequency (similar to variable duty cycle in conventional fixed frequency PWM) modulates the output voltage/current. When the input voltage is low, the switches will operate in boost mode by reducing the frequency below the natural resonant frequency. When the input is high it operates in buck mode by increasing the switching frequency above the resonant frequency.

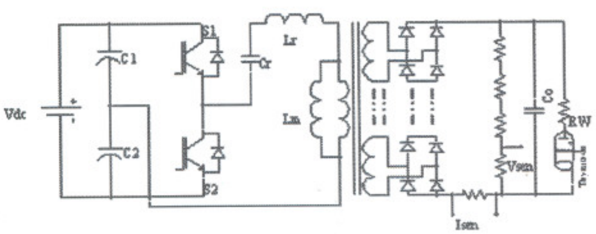

Fig.L.5.1: IGBT based LLC converter.

The switches S1 and S2 operate near 50% duty cycle at variable frequency from 30kHz to 50kHz. The half-bridge switches together with two series storage capacitors C1 and C2, resonant inductance Lr, magnetizing inductor Lm, and resonant capacitor Cr form the resonant tank, which is connected to the centre point of half bridge and the centre of series capacitors. A single die epoxy molded, dry type, step-up transformer with a turn's ratio of 1: 128 was designed and developed to get the required 35kV. The insulation level between the secondary with core and ground was tested at 80kV AC. The switches S1 and S2 are driven by complementary control signals delivered from NCP1395A controller. Switching frequency not that of duty cycle modulates the output voltage/current.

The prototype was developed using CM150DY-24H IGBT as switch, series inductor Lr= 35μH, Lm=172μH and series capacitance C_r=470nF. The transformer is made using 4 pair of U-101 ferrite N67 cores. The secondary of the transformer is divided into 8 sections, each one is rectified using full bridge rectifier and connected in series. This helps in getting voltage gradient, thus reduction in voltage isolation level between layers of the secondary winding. The high voltage rectifier was made using BYV26E diodes. There are 8 nos. of full bridge rectifiers each contains 44 diodes. The power supply was tested with a thyratron triggered pulse discharge R-C circuit. The capacitor was discharged through the thyratron to a non-inductive resistive load of 100 ohm. The non-inductive resistive load (RW) was prepared by using de-mineralized water and copper sulphate (pentahydrate, CuSO4.5H2O). Fig.L.5.2 shows the experimental results of the power supply with actual load. Fig.L.5.3 shows the first prototype of this power supply.

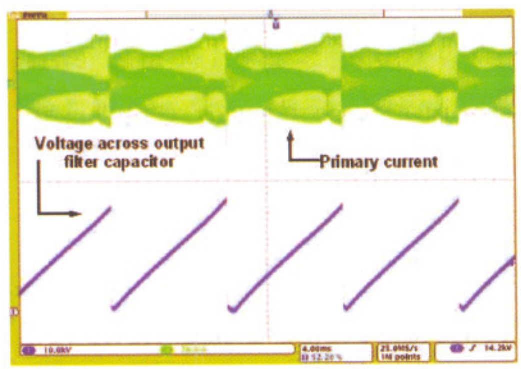

Fig.L.5.2: Experimental results Ch-1 primary current (50Amp/div.) Ch-2 Voltage across output capacitor. (10KV/div.) Working with capacitor charging pulsed discharge type of load.

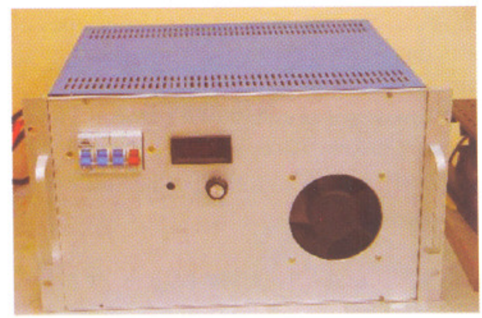

Fig. L.5.3: The prototype of the power supply

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