A.9: Two-quadrant power supply for atom cooling experiment

A 50 A, ±225 V current regulated bipolar power supply has been developed at PCDS, PSIAD, RRCAT. It is required by Atom Optics & Raman Spectroscopy Lab, Laser Physics Applications Section, RRCAT to energize the solenoid coil in atom cooling experiment.

The power supply operates on 415 V, 50 Hz three-phase ac mains. The main feature of this power supply is its ability to generate fast rising and falling current patterns of peak amplitude 50 A in inductive load at the output with 1 ms rise and fall time. These current patterns on the load with inductance and resistance values of 3.2 mH and 0.8 Ω respectively calls for a bipolar voltage of ±225 V. A two-quadrant switch-mode converter with IGBTs operating at 25 kHz is therefore chosen. A 2.4 kVA three phase step-down transformer, followed by a three-phase bridge rectifier and a low pass LC filter generates required dc link voltage. The schematic of power supply is shown in Fig. A.9.1.

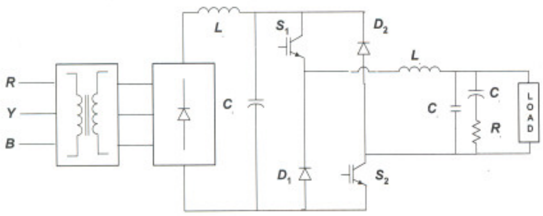

Fig. A.9.1: Power supply schematic

The value of input filter capacitor is chosen in such a way so as to maintain a minimum dc link voltage at the input of switching stage which is required for fast rise of output current from 0 to 50 A in 1 ms duration. It is because during ramp-up period, entire output current is drawn from the filter capacitor as input filter gets deactivated for such a short duration and this results in a droop at dc link voltage from its steady state value. Therefore, a trade-off is required to be made between capacitor value and maximum allowable dc link voltage droop during ramp-up period. Figure A.9.2 shows a graph between input filter capacitance and dc link voltage droop. Filter capacitance of 2 mF is finally chosen.

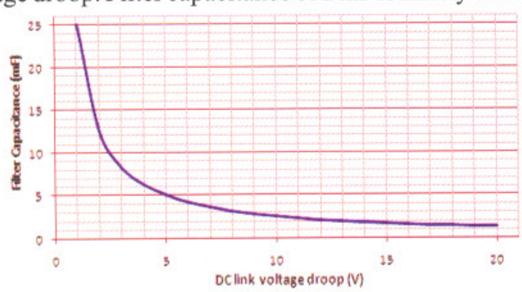

Fig. A.9.2: Filter capacitance v/s dc link voltage droop

To achieve fast rising and falling patterns in output current, a feed-forward loop is implemented in the control circuit which is in addition to feedback control scheme consisting of two loops: inner voltage loop and outer current loop. The feed forward loop is designed so that it operates only during rising and falling durations of the output currents by responding to a calibrated remote reference source. It is done because inductive nature of load results in inherently slow response of current loop and thus rendering it incapable to provide sufficient reference to the inner voltage loop which is required to raise output voltage and hence, current in a desired manner. Therefore, in order to achieve fast response during ramping periods the feed-forward loop bypasses the current loop for these durations and drives voltage loop so as to achieve desired ramping rates.

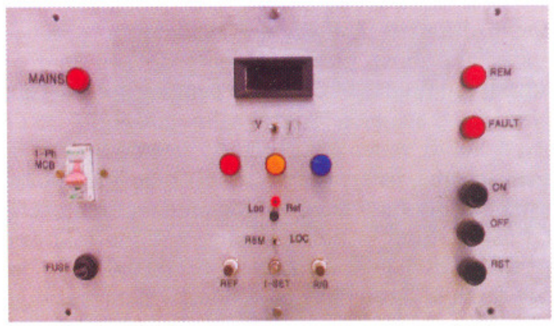

Fig. A.9.3: Power supply photograph

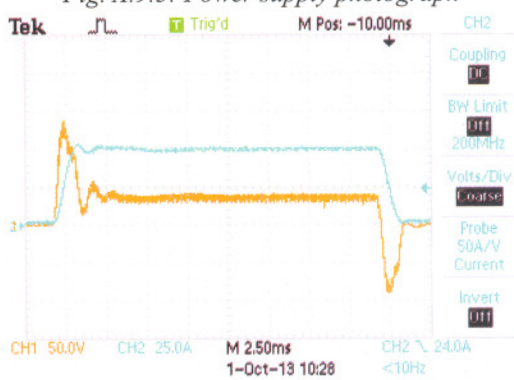

Fig. A.9.4: Output voltage and current waveforms: Ch 1- Output voltage, Ch 2- Output current

Figure A.9.3 shows photograph of two-quadrant power supply. Figure A.9.4 shows experimental waveforms of output voltage and current with ramp-up and ramp-down durations. In Fig. A.9.4, y-axis for Ch-1 shows output voltage with scale of 50V/div while y-axis for Ch-2 shows output current with scale of 25A/div. The x-axis has the scale of 2.5ms/div.

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