L.1: Development of an engineered two-beam high gain, Joule class pre-amplifier system for seeding kJ class Nd:Glass laser

A two-beam high energy Nd:Glass laser system is under development at RRCAT for high energy density physics applications. High energy Nd:Glass laser systems are based on multi-beam multi-pass architecture and consist of a fiber optic front end system (FOFES), pre-amplifiers and power amplifiers to deliver laser pulses of energy ranging from sub-kJ to 100's of kJ on the experimental targets. The power amplifiers require input pulse energy in the range of milli-Joules to few Joules. An engineered two-beam FOFES capable of delivering time synchronized and temporally shaped 40 nJ seed laser pulses of 3 ns duration, has already been developed. The FOFES has a provision of tailoring laser pulses in terms of pulse duration in ns range and arbitrary temporal shape to meet experimental requirements. To further amplify these seed pulses to Joule level, development of an engineered two beam laser pre-amplifier system capable of generating laser pulses of energy more than 4 J per arm with overall gain of 10^8 has been carried out. The schematic and photograph of the two beam pre-amplifier system are shown in Figures L.1.1(a) and L.1.1(b), respectively.

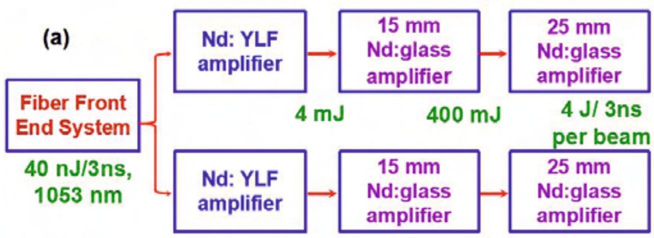

Fig: L.1.1: (a) Schematic diagram of the two-beam pre-amplifier system and (b) photograph of the two beam pre-amplifier system.

The Nd:YLF amplifier comprises of a 7 mm ϕ x 125 mm Nd:YLF rod pumped by 7 kW QCW diode stacks operating in four pass configuration realized by polarization discrimination. The amplifier provides a gain of 10^5 at a diode current of 110 A. This results in amplification of pulse energy from 40 nJ to 4 mJ with a beam size of ~3 mm and corresponding amplified spontaneous emission (ASE) background energy i.e., the energy with no seeding is ~70 µJ. A spatial modulator was also incorporated in this amplifier path for pre-correction of wavefront to compensate for wavefront deterioration in power amplifiers at later stages. The beam was magnified to ~12 mm using a 4X Galilean type beam expander for mode matching with 2^{nd} stage amplifier that consists of a 15 mm ϕ x 200 mm Nd:Glass rod pumped by 4 numbers of Xe flash lamps of arc length 180 mm. The laser pulses are further amplified to 400 mJ in double pass configuration at an electrical pump energy of 3.8 kJ. Subsequently, laser pulses are amplified to 4 J in next stage of double pass Nd:Glass amplifier consisting of a 25 mm ϕ x 300 mm Nd:Glass rod and pumped by 6 numbers of xenon flash lamps of arc length 280 mm with an electrical input energy of 6 kJ. The recorded oscilloscope traces of energy measurement at the output of 3^{rd} stage of each beam are shown in the Figure L.1.2.

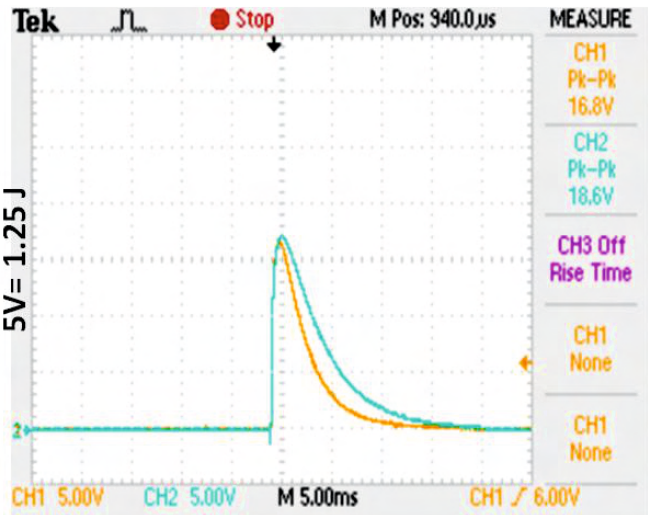

Fig. L.1.2: Oscilloscope traces of energy meter at the output of 3^{rd} stages of the pre-amplifier.

The pre-amplifier system is ready for the integration with high energy power amplifier stages. Modular assembly of all the sub-systems is for ease of integration and deployment. High gain system reduces the number of pre-amplifier stages, thereby reducing the complexity of the systems. The output energy of the pre-amplifiers can be varied in the range of ~10 mJ to ~4 J.

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