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Description and performance of the preamplifier for the National Ignition Facility (NIF) laser system*

John Crane, Mikael Martinez, Bryan Moran, Curt Laumann, James Davin,
Raymond Beach, Brad Golick, Russ Jones, Ron Wing,
John Braucht, Michael Perry, and Scott Mitchell

Lawrence Livermore National Laboratory
P.O. Box 808, Livermore, CA 94550
Phone: (510) 422-0420; FAX: (510) 422-7748; email: crane1@llnl.gov

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The preamplifier for the NIF laser system takes the 1 nJ, shaped and modulated pulses generated in the master oscillator room, amplifies them to the 10 J level, spatially shapes them to precompensate for the gain profile of the main amplifiers and adds spectral bandwidth and dispersion for beam smoothing. Four subsystems form the preamplifier: a diode-pumped, Nd:glass regenerative amplifier; a spatial shaping optical system, an optical system for smoothing by spectral dispersion, and a 45 mm rod amplifier. All four of these optical subsystems will be housed in the preamplifier module (or PAM) along with the energizing, control, and diagnostic instrumentation. In this paper we describe the current design and performance of this high-gain preamplifier.

The regenerative amplifier is a folded-linear, TEM_{00} cavity that must be able to contain a 20 ns long, temporally-shaped pulse. At either end of the cavity are diode-pumped, 5X50 mm rod amplifiers that are end pumped by 48 bar, diode arrays. The diode light is focused with micro-lenses into a tapered lens duct that funnels light down into the end of the 5mm diameter laser rod.[1] Each rod stores about 300 mJ of energy in the upper laser state from 2 kW of optical pump power in a 350 μs pulse. The total available energy in the cavity eigenmode is about 60 mJ. The 1 nJ input pulse is amplified to 10 mJ in about 15 round trips in the regen, requiring a total gain of 10^7. To preserve the specific temporal shape of the input pulse, the regen is limited to a square-pulse-distortion of 1.2. To achieve an acceptable energy balance among the 192 arms of the laser, the regen must have a pulse-to-pulse stability < 3% rms.

The diffraction-limited Gaussian pulse emerging from the regen is formed into a square pulse that is spatially shaped in both transverse dimensions to compensate for the nonuniform spatial gain profile in the rod amplifier as well as the large aperture slab amplifiers. The square beam illuminates a serrated aperture that is relay-imaged through the rest of the laser system. A second optical system for smoothing by spectral dispersion (SSD) is included in the preamplifier module after the spatial beam shaping section. Although designs for both 1-dimensional and 2-dimensional smoothing have been considered, we will describe the current design of the preamplifier which includes 1-D SSD.

The second laser system in the preamplifier contains a 45 mm diameter, flashlamp-pumped, rod amplifier in a four-pass optical configuration. The input leg contains a 45 mm Faraday rotator that provides isolation of the regen from backward traveling pulses from the large amplifiers. The rod amplifier, which was designed and built at LLNL for the Petawatt and NIF preamplifier, is a 12 lamp design and produces a single-pass gain of 12-14. The total gain of the four-pass amplifier is 10^4 and the square-pulse-distortion is less than 2. The square-shaped beam produced in the beam shaping section is relay-imaged through the four-pass system producing up to 12 J at the output of the preamplifier. In our presentation we will discuss the design and performance of the preamplifier and how it integrates with the rest of the NIF laser system.

1. R. Beach, P. Reichert, W. Benett, B. Freitas, S. Mitchell, S. Velsko, J. Davin, and R. Solarz, "Scalable diode-end-pumping technology applied to a 100 mJ, Q-switched Nd^{3+}:YLF laser oscillator", Opt. Lett. **18**, 1329 (1993).

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