

Conf-9506179--1

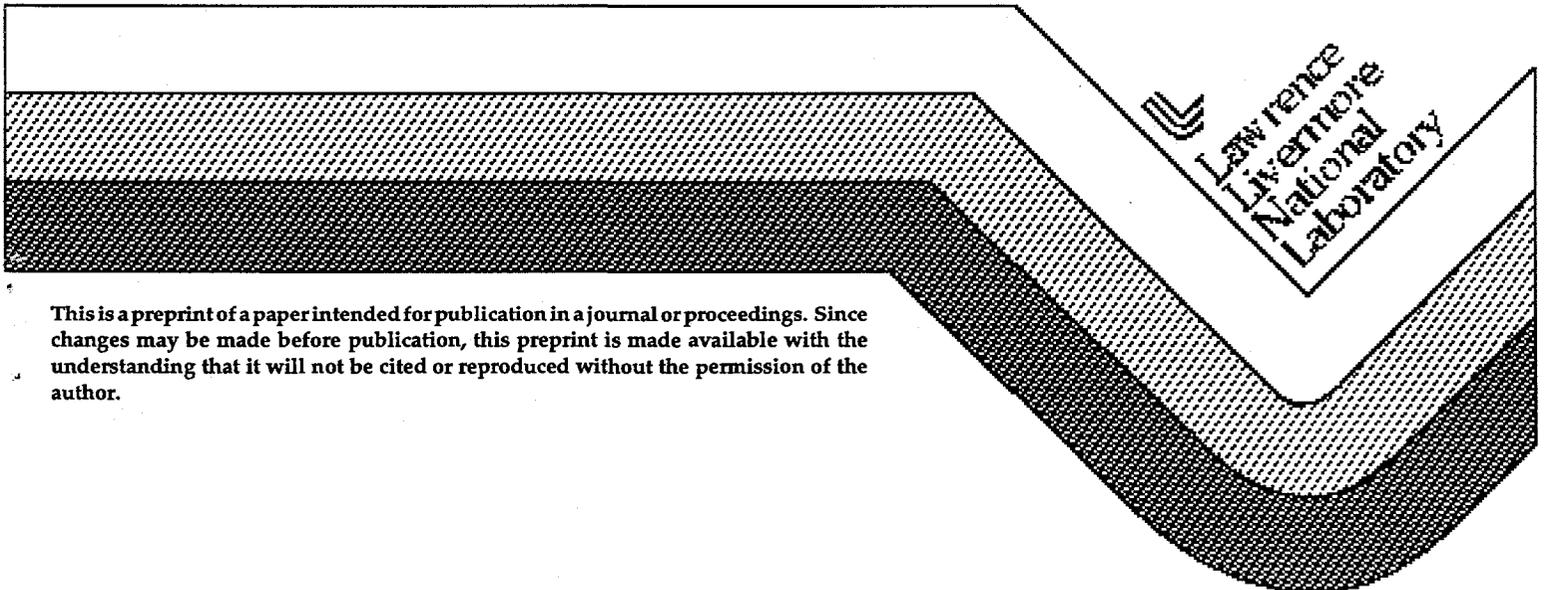
UCRL-JC-120517
PREPRINT

Optical Pulse Generation Using Fiber Lasers and Integrated Optics

R. B. Wilcox, D. F. Browning, S. C. Burkhart, and
B. W. VanWanterghem

This paper was prepared for submittal to the 10th International
Conference on Integrated Optics and Optical
Fibre Communication
June 26-30, 1995 Tokyo 113, Japan

March 27, 1995



This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

no

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Optical Pulse Generation Using Fiber Lasers and Integrated Optics

R. B. Wilcox, D. F. Browning, S. C. Burkhart, and B. W. VanWanterghem

University of California
Lawrence Livermore National Laboratory
P. O. Box 5508, Livermore, CA 94551

Abstract

We have demonstrated an optical pulse forming system using fiber and integrated optics, and have designed a multiple-output system for a proposed fusion laser facility. Our approach is an advancement over previous designs for fusion lasers, and an unusual application of fiber lasers and integrated optics.

Introduction

High peak power lasers for fusion and high temperature physics use a low power pulse forming system followed by a power amplifier. The proposed National Ignition Facility (NIF) has 192 power amplifier beamlines, each of which requires a temporally shaped input pulse, independently variable to achieve power balance on target. Considerations of laser architecture for supplying each of these beamlines from a central location (the "master oscillator room") were crucial in the design of the pulse generation system. The current design replaces bulk optic transport with fibers, eliminating large opto-mechanical subsystems. Temporal pulse forming is accomplished using low voltage integrated optic modulators. We have demonstrated the principles of one beamline on the Beamlet laser system, with excellent results.

Figure 1 gives an overall view of the pulse generation and preamplification subsystem designs. The following descriptions track the optical signal path in the master oscillator subsystem.

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48

Optical Pulse Generation
R. B. Wilcox

Master Oscillator Subsystem

The master oscillator system provides light inputs to the 192 pulse shaping modulators, in the form of 2.5W, 30ns pulses. Four oscillators provide four different wavelengths separated by 10 angstroms, near 1053nm, and each wavelength is amplified, split, and sent to 48 of the 192 outputs. The oscillator design is shown with the amplification and splitting hardware in figure 2. In the Beamlet demonstration system, we have used a diode-pumped YLF ring laser to provide one output at one wavelength.

Both the oscillator and the subsequent amplifiers have been designed with ytterbium-doped silicate fiber as the gain medium. This material has a broad gain bandwidth which covers the spectral region of interest. These fibers have a smaller stimulated emission cross section and longer fluorescence lifetime than neodymium in silicate glass (1), resulting in desirable attributes of higher saturation fluence and lower amplified spontaneous emission. Experiments have shown that Yb fiber lasers can operate efficiently when pumped with diode lasers, and can be Q-switched to produce energetic pulses (2).

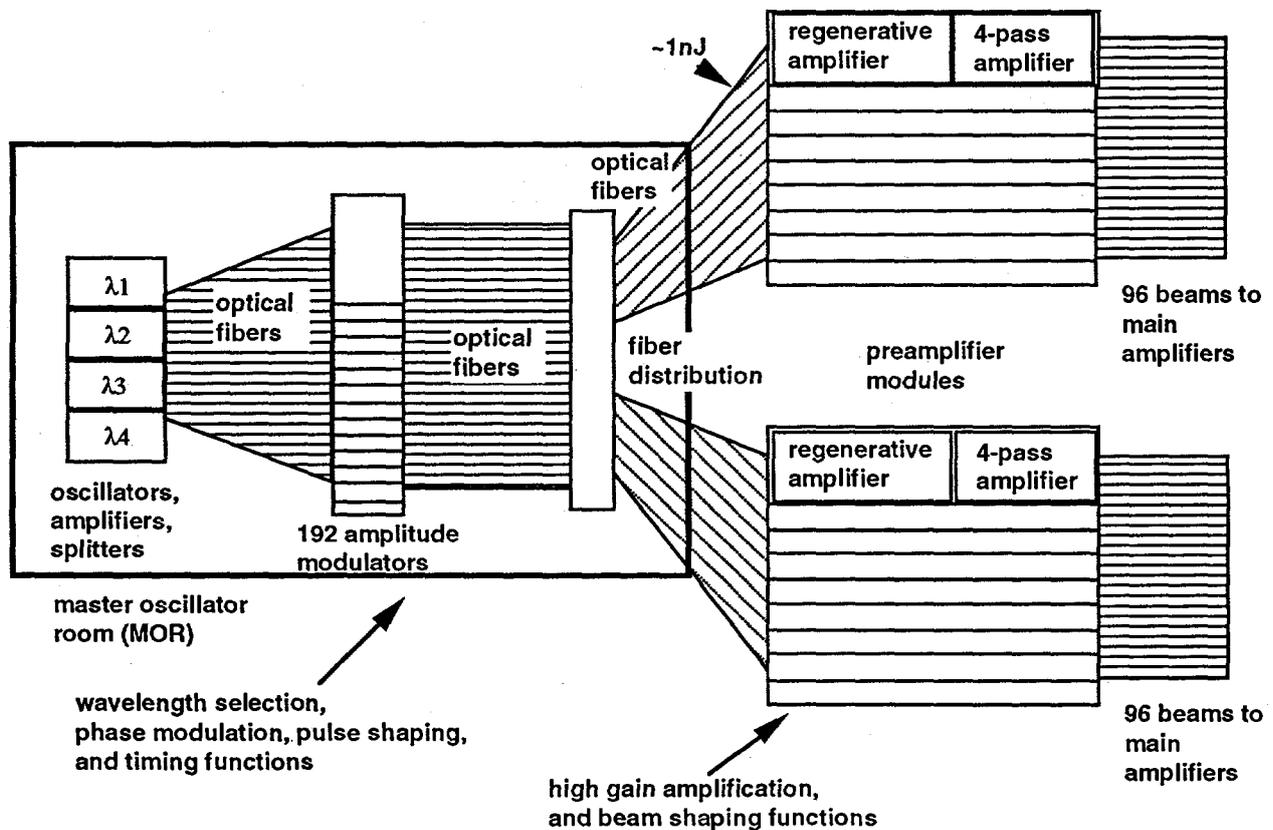


Figure 1. The overall front end design for the proposed National Ignition Facility.

Optical Pulse Generation

R. B. Wilcox

The oscillator design is a diode-pumped, Q-switched, single-longitudinal-mode-fiber ring laser. Single mode operation is produced by wavelength selection techniques employed in erbium-doped fiber lasers used in communications (3). A fiber Fabry-Perot etalon selects the cavity mode. The Q-switch is an integrated optical waveguide modulator, similar to the extra cavity modulators.

Amplification and splitting To distribute the light to the modulators, the oscillator pulse is amplified and split in two stages. Each fiber amplifier in the system has a gain of 100 and is pumped by a 910nm diode laser. The design is similar to that used in commercial fiber amplifiers. In order not to burden the dynamic range of the subsequent modulators, the fiber amplifiers are run below saturation to avoid excessive pulse shape distortion. We are currently testing Yb:silica fibers and other gain media in a pulsed amplifier configuration to determine the optimal core parameters. In the current technology demonstration, no amplifiers are used since the oscillator provides sufficient peak power.

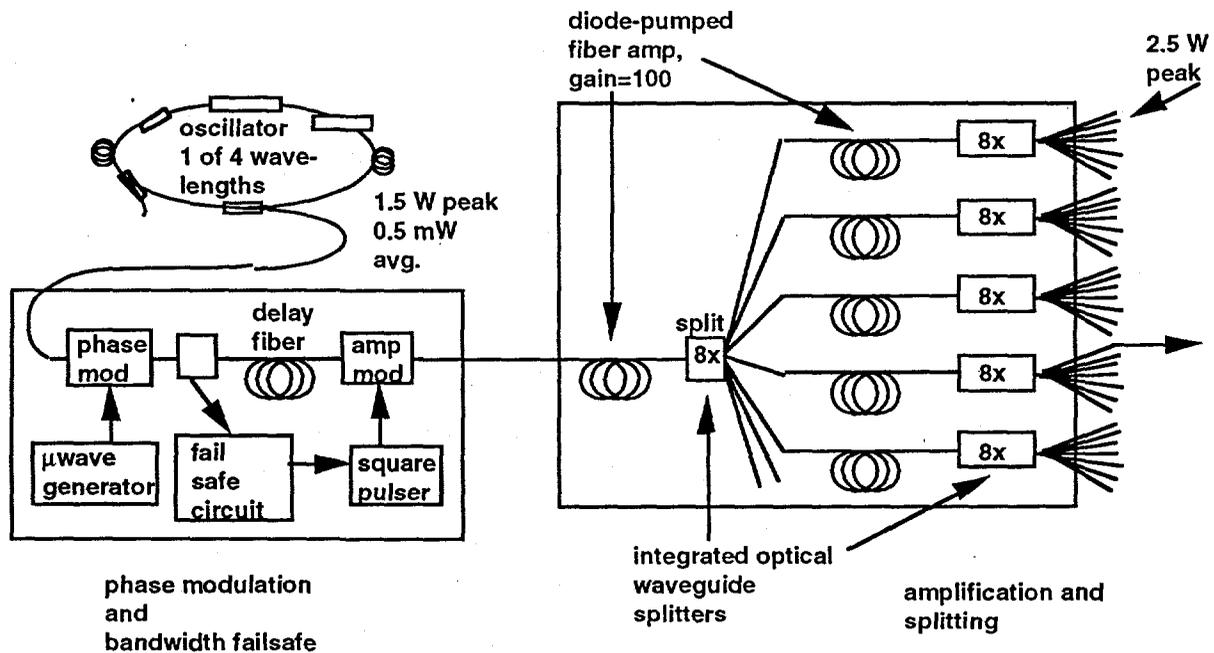


Figure 2. The master oscillator subsystem.

Polarization maintaining (PM) fiber is used to ensure insensitivity to temperature effects. The components in the signal line are specified to maintain polarization extinction better than 1%.

Optical Pulse Generation

R. B. Wilcox

Amplitude Modulator Subsystem

The NIF amplitude modulator system will provide temporally shaped optical pulses of 100ps to 20ns duration. The modulator device is housed in a chassis along with bias and pulse generators, as shown in figure 4, and comprises a programmable arbitrary optical waveform generator. In the demonstration system, we use a simple, manually variable electrical generator. We are developing a programmable system based on high-speed FETs, and commercial pulse generators.

The modulator chip

The amplitude modulators are lithium niobate, integrated optical waveguide devices, similar to those used for digital communications. A similar device has been tested on the Beamlet demonstration laser with excellent results (5).

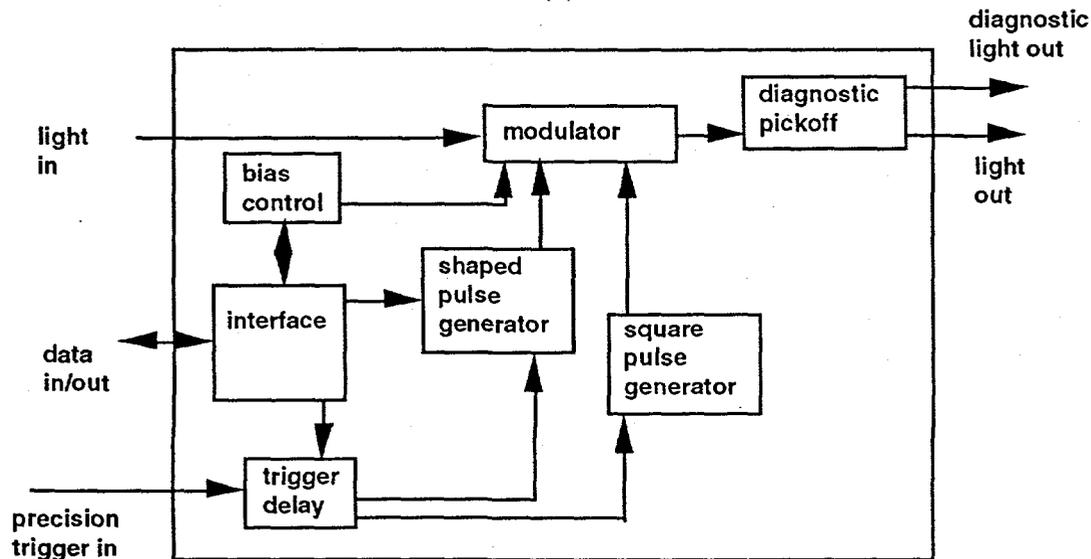


Figure 4. The amplitude modulator chassis.

The modulator chip has two amplitude modulators optically in series, to increase the on/off extinction ratio, and to provide for two separate modulation inputs. One input defines the shape of the optical pulse, and the other applies a square gate to sharpen the rise and fall times and remove any spurious post-pulse signals created by the shaper. The on/off extinction is greater than 50dB.

Conclusion

We have employed waveguide optics to generate temporally shaped optical pulses. A design based on this principle has been demonstrated, and we are currently extending this technology for a more complex system designed for the next generation fusion laser.

Optical Pulse Generation

R. B. Wilcox

References:

1. E. Snitzer, "Laser Emission at 1.06μ from Nd - Yb Glass," *IEEE J. Quant. Elect.* **2**, (9), 562-566 (1966).
2. D. C. Hanna, R. M. Percival, I. R. Perry, R. G. Smart, P. J. Suni, A. C. Tropper, "An Ytterbium-doped Monomode Fiber Laser," *J. Mod. Opt.*, **37**, (4), 517-525 (1990).
3. K. J. Vahala, J. W. Dawson, N. Park, S. Saunders, "Tunable Single-Frequency Erbium Fiber Ring Lasers," *Proc. of CLEO 1993--Technical Digest Series*, **11**, 484-487 (1993).
4. R. B. Wilcox, W. Behrendt, D. F. Browning, D. R. Speck, B. M. VanWanterghem, "Fusion Laser Oscillator and Pulse-Forming Systems Using Integrated Optics," *SPIE Conf. Proc.* **1870**, 53-63 (1993).