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S. C. Burkhart, C. Bibeau, C. W. Laumann
J. K. Lawson, E. H. Padilla, D. R. Speck,
T. L. Weiland, and R. B. Wilcox

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S. C. Burkhart, E. H. Padilla, T. L. Weiland, and R. B. Wilcox

Lawrence Livermore National Laboratory
P. O. Box 5508
Livermore, CA 94550
(415) 423-2061

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Temporally shaping the target irradiation pulse is crucial for the realization of inertial confinement fusion. We have developed a versatile electrooptic technique for making shaped pulses at 0.35 μm on Nova.

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Temporally shaping the pulse that irradiates the target is crucial for the realization of inertial confinement fusion. Optimally shaped pulses are tailored to minimize the energy, and thus the size and cost of the drive energy source, required to reach the high densities and temperatures necessary for fusion. Since its activation in 1984, Nova has provided shaped laser pulses to study laser-target interactions. Earliest experiments used temporally square pulses that are shaped by a Pockel's cell system (Fig. 1) at the master oscillator to compensate for saturation in the laser amplifier.(1) More recently we have increased the flexibility of our pulse shaping system to make possible the generation of a variety of interesting pulses. One of the shapes of interest recently was one where the main pulse was preceded by two initial pulses, or "pickets" (Fig. 2). Such a pulse can provide the desired drive profile to the target while maintaining high frequency conversion efficiency. Another approach is a continuous profile. Figure 3 shows a four-step laser pulse at

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0.35 μm, which we recently achieved with a maximum contrast of 100 to 1. The key challenge in generating these pulses was in electrical pulseshaping technology.

A fundamental advancement in electrical pulseshaping was the recent paper by Bruckstein and Kailath(2) where inverse scattering theory was applied to reflecting non-uniform transmission lines. They showed that given an incident pulseshape and a desired reflected pulseshape, a transmission line could be synthesized which would produce the desired output. That work has been extended and experimentally verified(3) on the Nova pulseshaping system, where the electrical pulse was used to drive the Pockel's cell as shown in Fig. 1. Realization of the impedance profile has been done using both open microstrip and closed microstrip (stripline) construction on printed circuit board. This fabrication technique has allowed us to generate electrical pulses for both the high contrast continuous and the "picket fence" master oscillator pulses. Initially the non-uniform transmission lines were manually cut from a printed circuit board, a labor intensive process which we continue to do for many of the prototype boards. It is now possible to have them made from a photographic negative exposed by a precision photoplotting machine. The success of the synthesis and fabrication techniques is graphically demonstrated in Fig. 2, which compares the desired and experimentally measured electrical pulses for the "picket fence" pulse. The transmission line for this result was made on precision teflon/fiberglass printed circuit board which is standard to the microwave industry.

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The desired electrical pulseshape at the shaper Pockel's cell is the result of backing out system nonlinearities from the desired pulseshape at the target to the Pockel's cell. These nonlinearities include frequency conversion, laser amplifier gain saturation, and the steady state response of the Pockel's cell. We have largely depended on past work[4] in deconvolving these effects. The Pockel's cell also acts as a low pass filter on the electrical drive pulse, which we have compensated for by using deconvolution techniques.

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References

[1] R.B. Wilcox, "Photoconductive pulseshaping device for the Nova master oscillator," Laser Part. Beams, Vol. 4, pp. 141 (1986).

[2] A. M. Bruckstein and T. Kailath, "Inverse Scattering for Discrete Transmission-Line Models," *SIAM Review*, Vol. 29, pp. 359-389, Sept. 1987.

[3] S. C. Burkhart and R. B. Wilcox, "Arbitrary Pulse Shape Synthesis via Non-uniform Transmission Lines," Submitted for publication in the *IEEE Trans. Microwave Theory Tech.*

[4] J. K. Lawson, D. R. Speck, C. Bibeau, T. L. Weiland, P. H. Chaffee, "Pulse shaping on the Nova laser system," Conference on Lasers and Electro-Optics, 1989 Technical Digest Series, Vo. 11 (Optical Society of America, Washington, D.C., 1989) paper WD2.

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Figure Captions

Figure 1. Schematic layout of the Nova pulse shaping system. A pulse with a typical width of 1 ns to 3 ns is shaped and then sliced from the long pulse oscillator. Photoconductive silicon switches.are used to switch the charged lines.

Figure 2. Electrical pulse necessary to generate a suitable "picket fence" drive at 0.35 μm. The desired electrical pulse is shown overlaid with the experimentally measured pulse. The last narrow pulse is an unwanted artifact of the measured pulse, but it occurs after the main pulse and is sliced away.

Figure 3. Experimentally achieved relative power vs. time of a four-step laser pulse at 0.35 μm produced from a single Nova beamline. Maximum contrast is close to the desired 100 to 1.

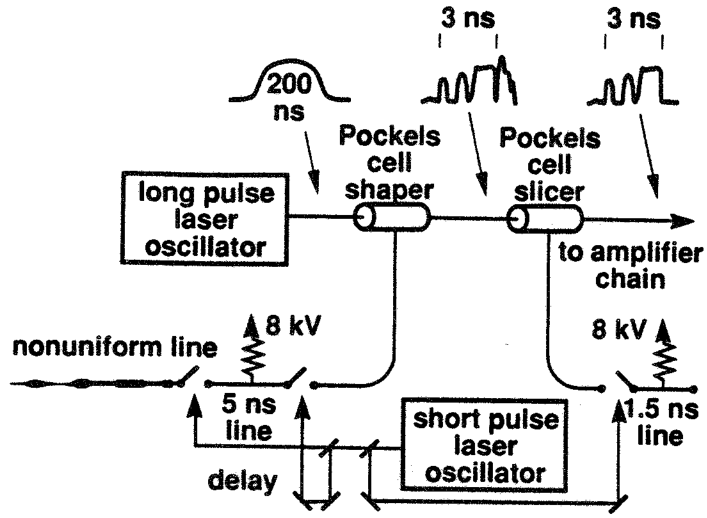

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Figure 1

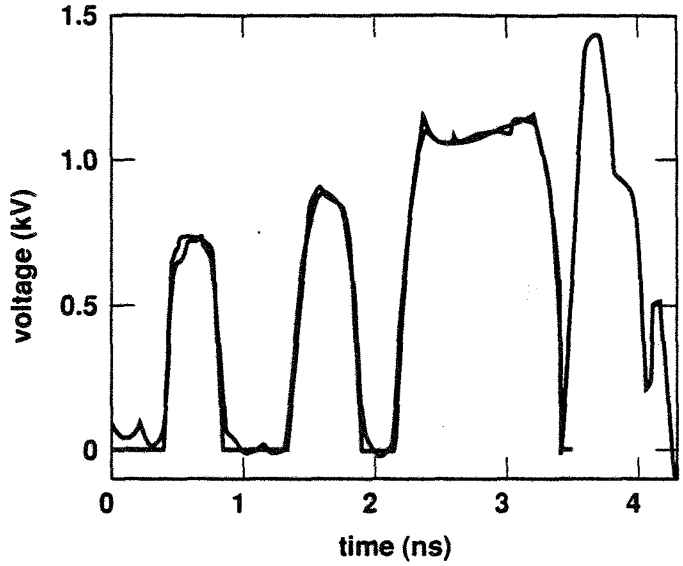

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Figure 2

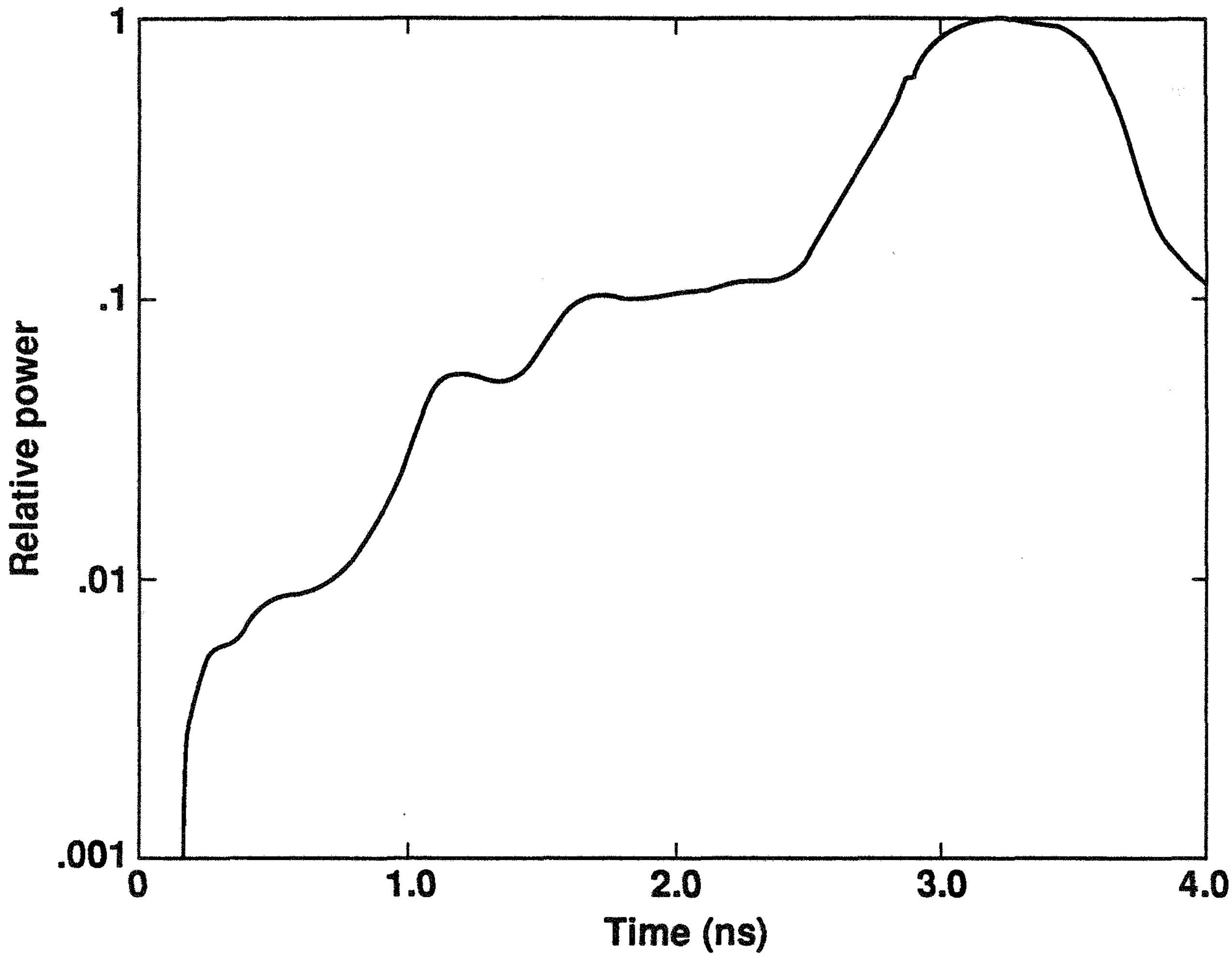

Figure 3

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