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# Nearly arbitrary pulse shaping in mode-locked gain-modulated SOA-fibre laser


*B. Nyushkov[1,2], S. Kobtsev[1], A. Ivanenko[1], S. Smirnov[1]*

*[1]Novosibirsk State University (Novosibirsk, Russia)*

*[2]Novosibirsk State Technical University (Novosibirsk, Russia)*


## INTRODUCTION

We present an efficient method of electronically-controlled generation of periodic arbitrary optical waveforms in a hybrid laser composed of a semiconductor optical amplifier (SOA) and an all-fibre cavity. We show that appropriate shaping of the electric pulses, which synchronously pump the SOA-fibre laser, enables mode-locked lasing with desirable temporal pulse profiles if the induced gain modulation is fully above the lasing threshold.

## OBJECTIVES

**The best solution for arbitrary shaping of laser pulses should:**

- ✓ **rely on intracavity laser radiation control**
- ✓ **precisely reproduce desired waveforms**
- ✓ **allow external synchronization**
- ✓ **be energy-&-cost efficient**

## EXPEREMENT

**Figure 1** shows experimental installation. An all-fiber ring-linear laser cavity employs a fiber-coupled SOA, a 50% output coupler, and an optical circulator. The latter is terminated with a fiber Bragg grating (FBG) which forms an intracavity bandpass spectral filter centered at 1540 nm. The cavity is extended by a 2.4-km long normal dispersion fiber (NDF) and a 2.4-km long non-zero dispersion shifted fiber (NZDSF). The total cavity length of **4.8 km** allows synchronous pumping at a repetition rate of **43.35 kHz** and thus enables laser pulse patterning and optical waveform shaping within the cavity round-trip time of **$T_c$=23 μs**.

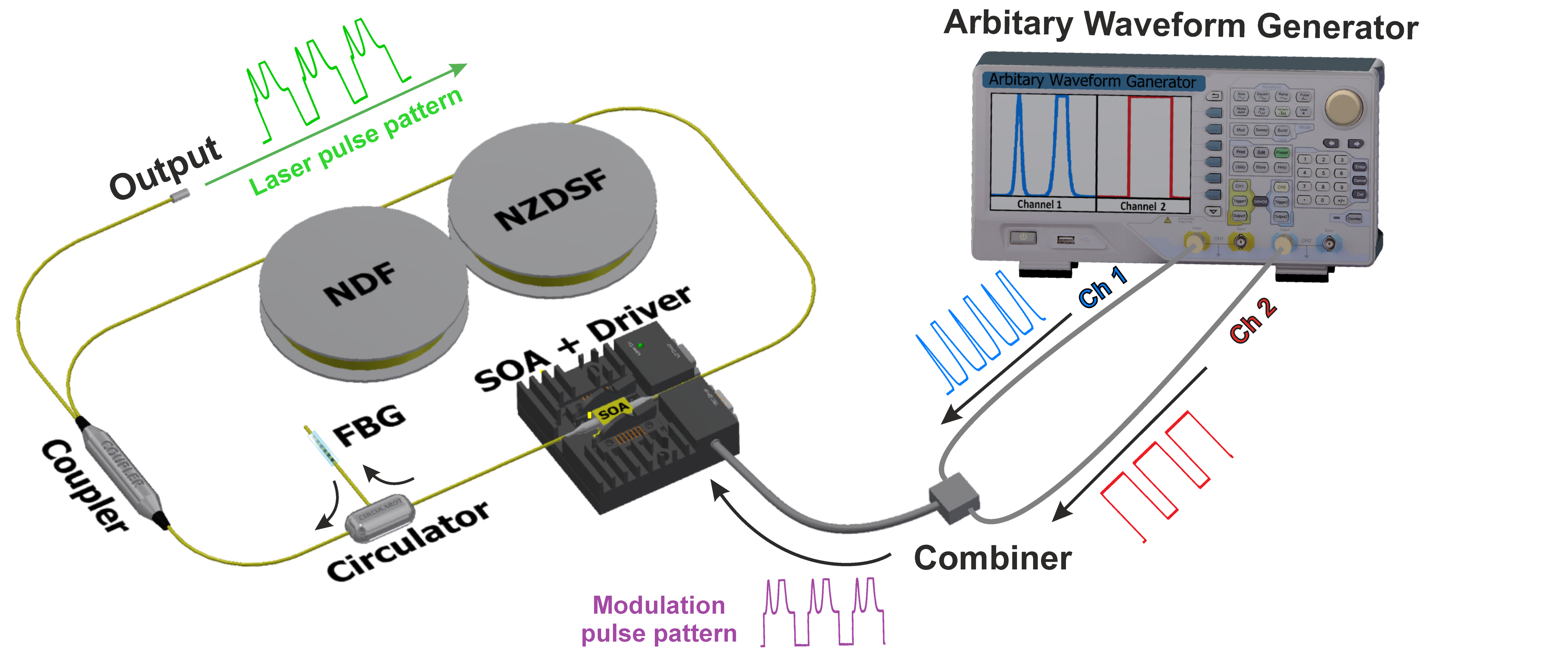


**Fig. 1** Mode-locked gain-modulated* SOA-fibre laser implemented for generation of arbitrary laser pulse patterns and waveforms.

* the modulation pulse patterns/waveforms are formed by using a programmable dual-channel radiofrequency arbitrary waveform generator and modulate pumping current of the SOA.

## RESULTS

Synchronously pumped mode-locked operation with the laser radiation structured and shaped as a replica of the modulation (i.e. pumping) pulse pattern/waveform is obtainable if the repetition period of the modulation pulse pattern equals the cavity round-trip time ($T_{pattern}=T_c$).

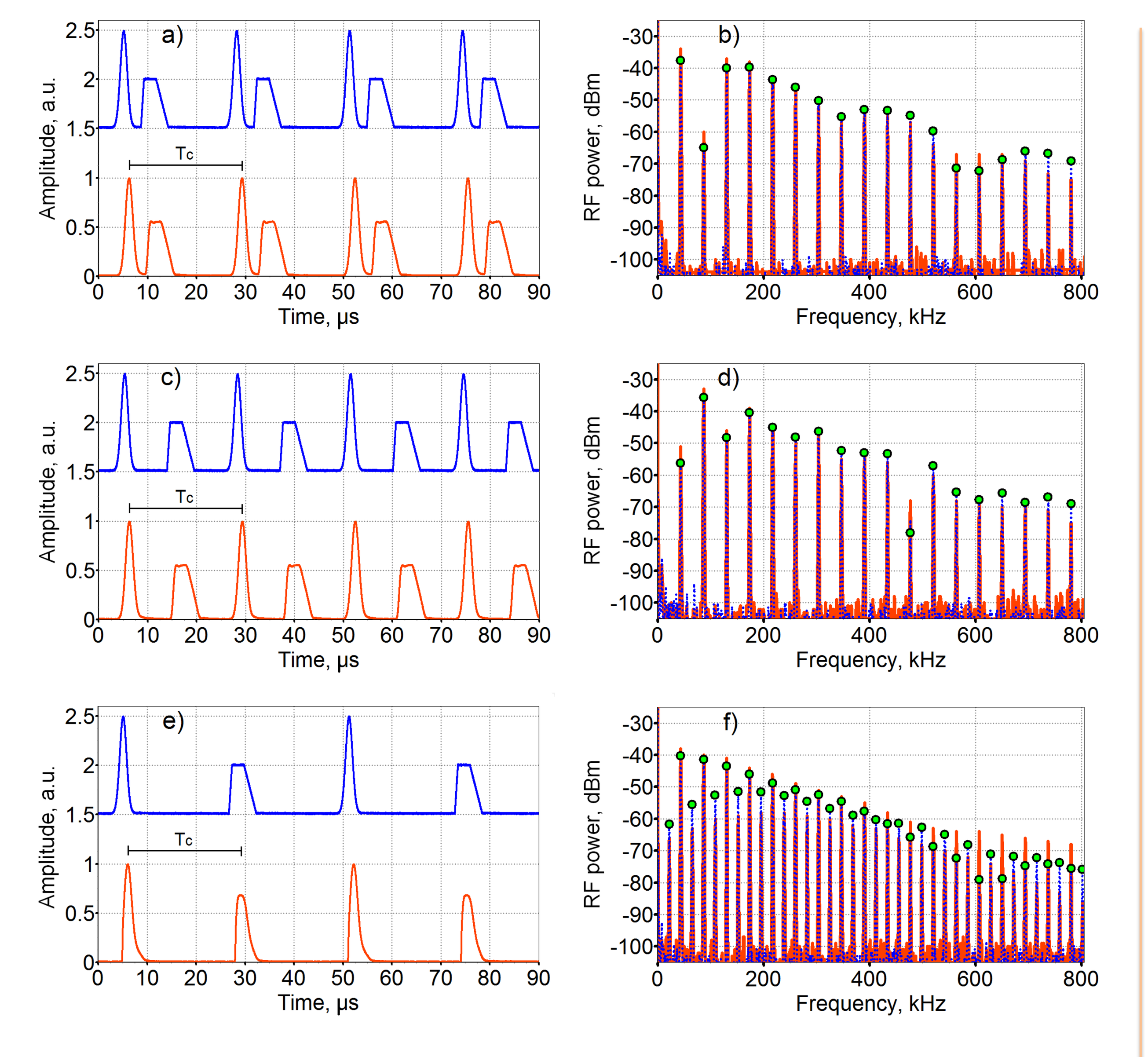


**Fig. 2** Oscillograms (a, c, e) and corresponding RF spectra (b, d, f) measured for modulation patterns (blue) and for laser pulse patterns (red). Green circles indicate theoretical spectra of desirable patterns.

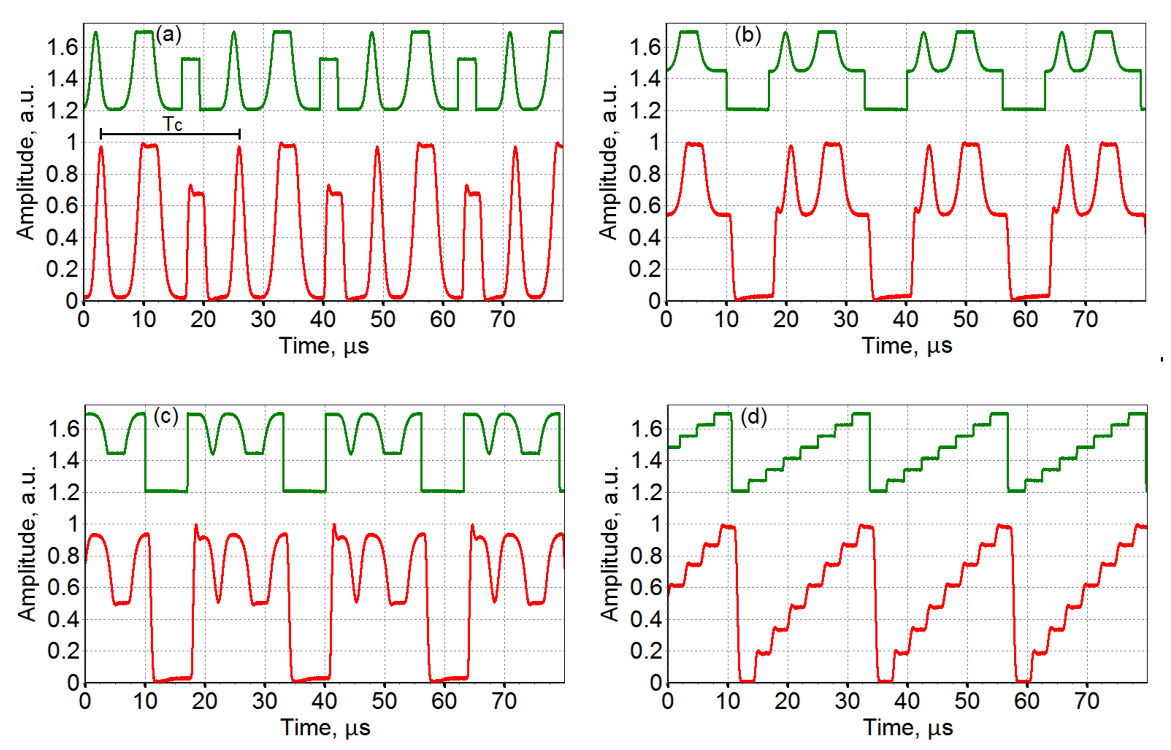


**Fig. 3** Oscillograms of complicated forms of driving electrical signal (green curves) and resulting laser pulse patterns/waveforms (red curves).

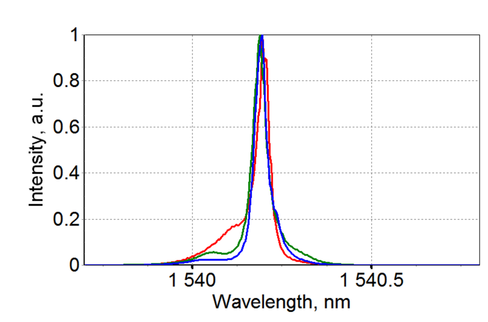


**Fig. 4** Optical spectra of generated laser waveforms: blue curve corresponds to the waveforms of Fig. 3(b), green curve to Fig. 3(c), red curve to Fig.3(d).

## CONCLUSION

Mode-locked lasing driven by synchronous pumping can stably sustain nearly arbitrary laser pulse patterns/waveforms repeatable on each cavity round trip. Considering nearly-1-ns response time of conventional SOAs, the investigated method of lasing can provide nanosecond temporal resolution for electronically controlled high-precision pulse shaping.


*e-mail: s.kobtsev@nsu.ru*



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