Optical chaos based on a laser diode with positive feedback

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Goals

Globally we would like to transmit a high-frequency signal in encrypted form.

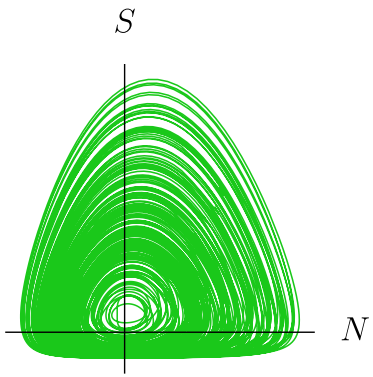
Here, we will consider the following steps towards this goal:

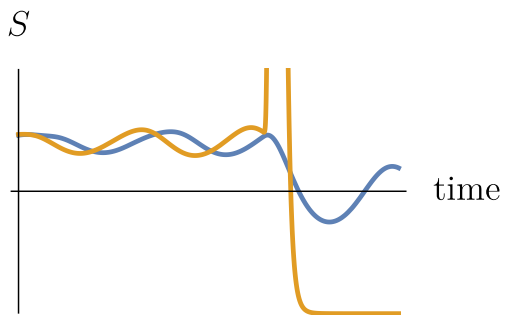
- dynamical chaos and synchronization (to encrypt and decrypt signal);
- theory of the laser evolution and its adaptation under our needs;
- realization of the positive feedback in laser: theory, modeling and practice.

Definition of dynamic chaos and applications

Map[1] f is **chaotic**, if

- periodic orbits are dense everywhere;
- orbits are mixed;
- f sensitive to the initial conditions.





Possible applications:

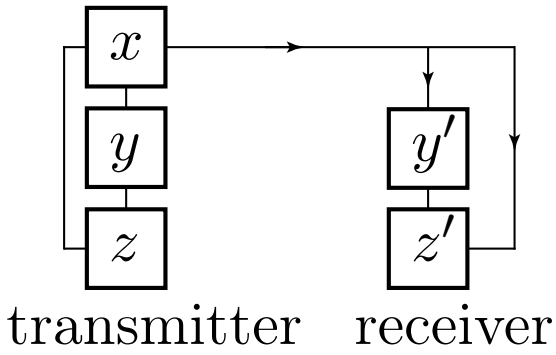
- random numbers generation;
- signal encryption.

[1] W. Hirsch, S. Smale, Introduction to Chaos.

Synchronization

Possible[2] synchronization of chaotic systems:

enough to transmit
part of the signal;
configure system parameters.



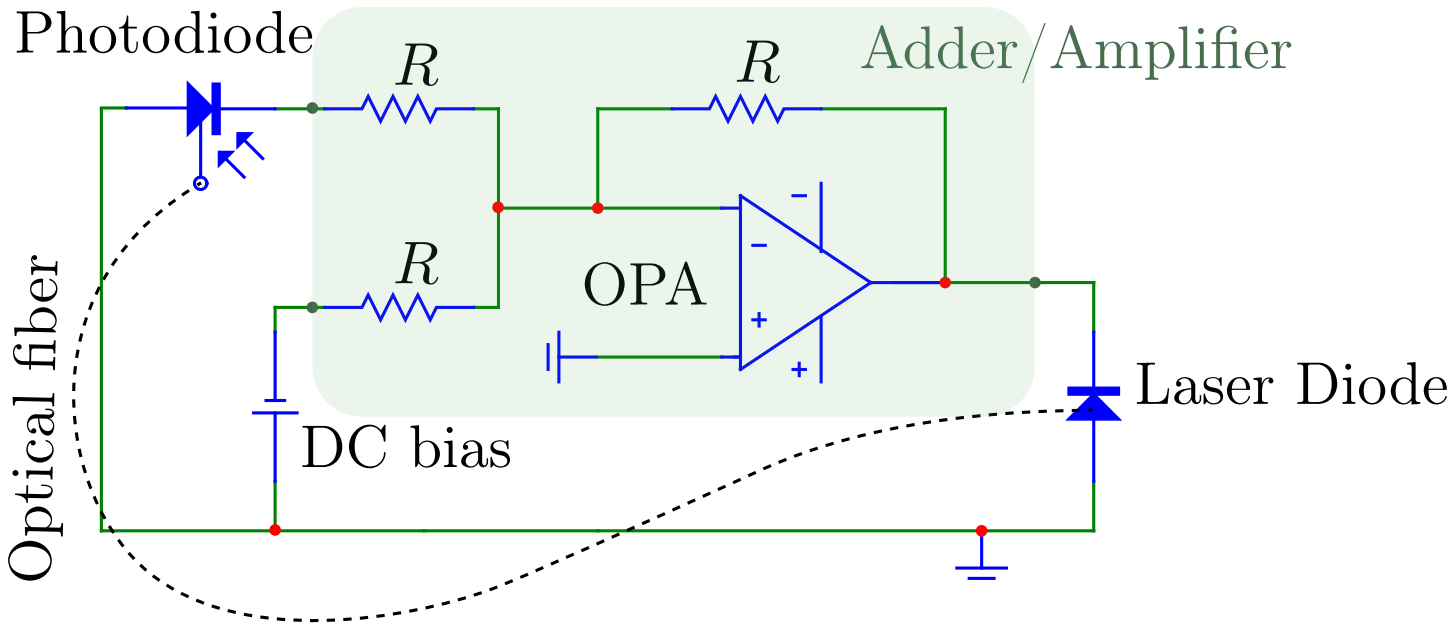
The use of optics to transmit the signal allows to achieve a greater bandwidth of the channel.

UHFO (ultrahight frequency oscillations) is a characteristic to optic systems.

[2] M. Pecora, L. Carroll, Synchronization in Chaotic Systems, 1990.

Scheme

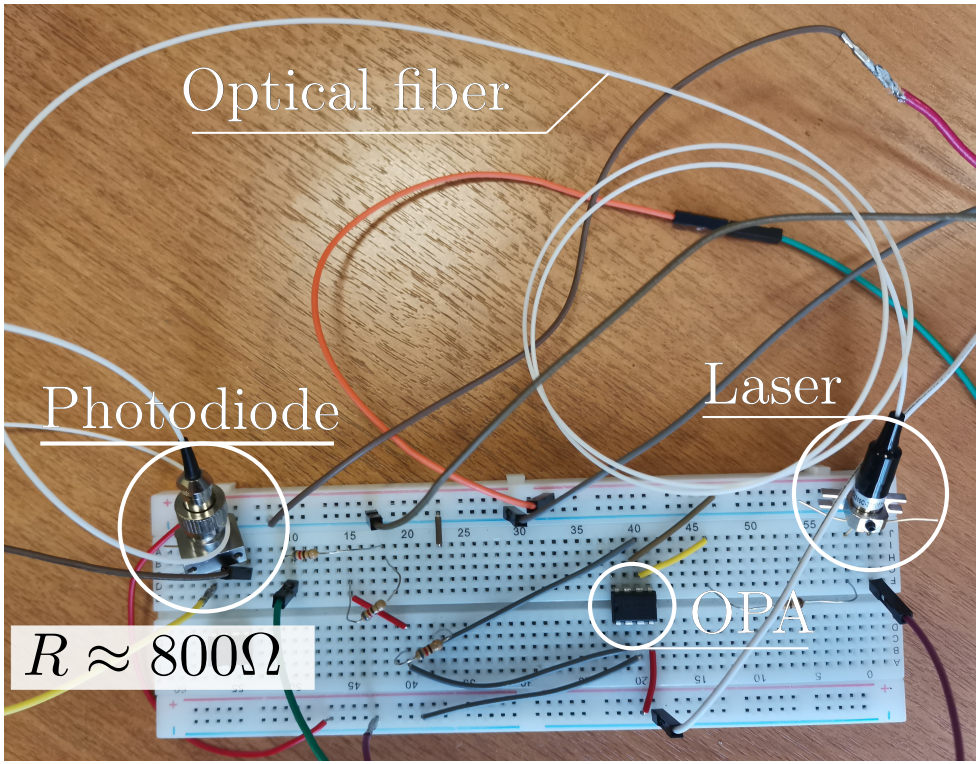
After several experiments came to this scheme with the summing amplifier:

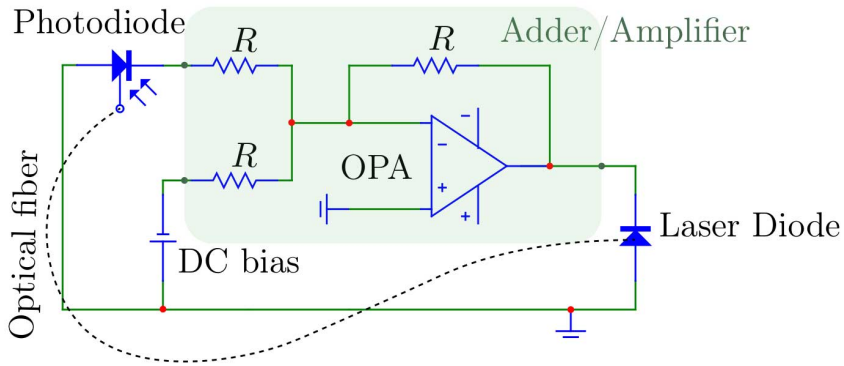


Photodiode power is enough to not use an additional amplifier.

Realization

For testing, the assembly was carried out on the dumping board.

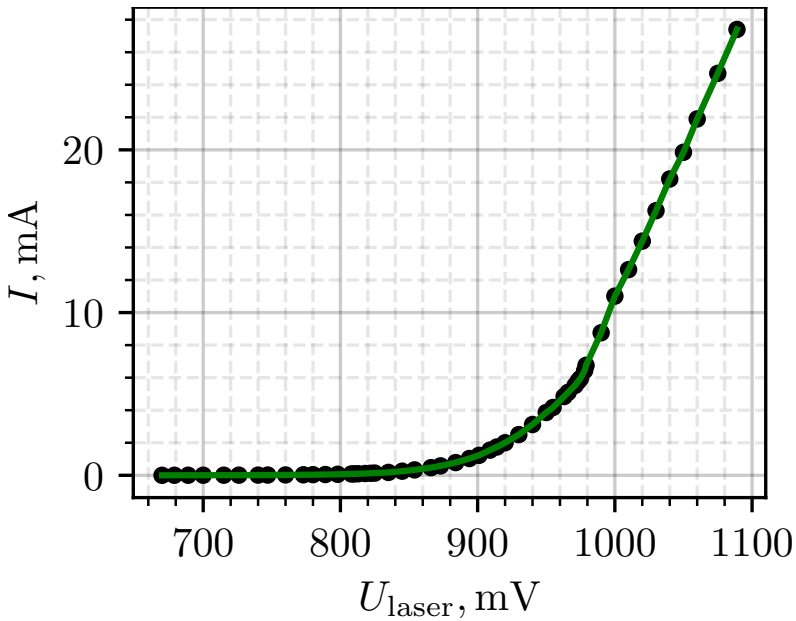


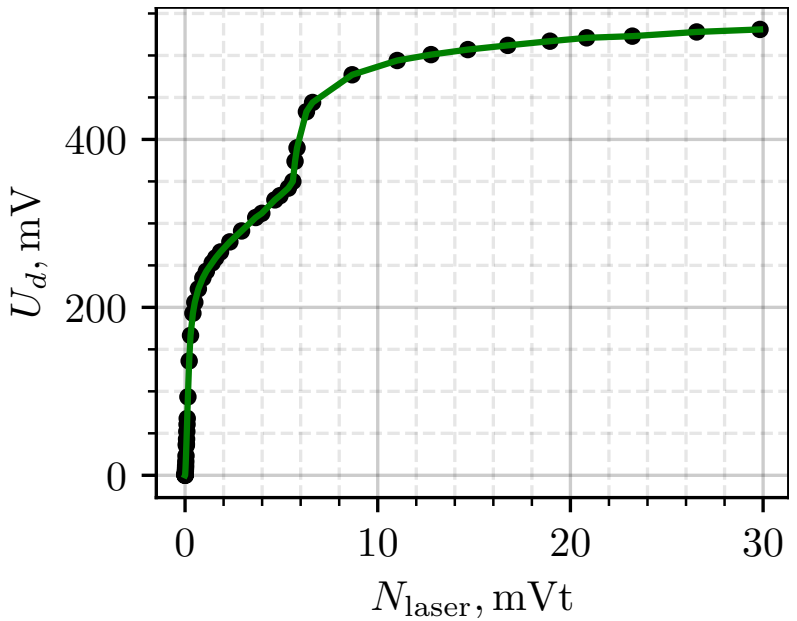


Thus, a scheme with positive feedback was implemented.
However, no desired oscillations were observed.

I–V curve

Makes sense to be in the most sensitive range, it was measured:
- I-V curve for a laser
- the dependence of the ph. diode voltage on the laser power.

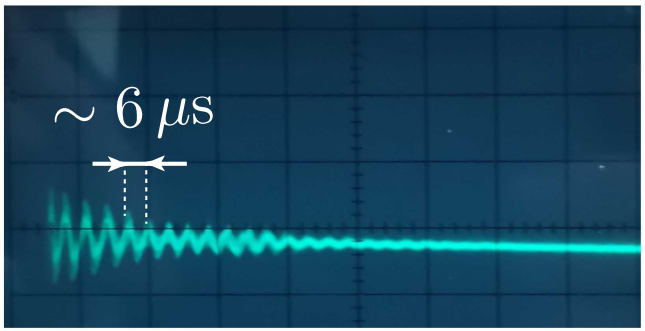




So, laser voltage range of $0.95 - 1.00$ mV selected.

Problems

With used amplifiers, the following oscillations at the amplifier output with DC power can be observed:



This is due to the instability of the amplifier. This instability can be eliminated by the adjustment of the scheme.

The main problem is that desired oscillations ~ 10 ns.
Thus, we proceeded to experiments with faster amplifiers.

Problems

However, it was not possible to move to the chaotic regime in the laser. Possible cause of the problem may be

- parasitic capacity and inductance,

In terms of solutions – neatly soldered scheme.