# ABSTRACT


The aim of the doctoral thesis was to analyze the process of nanosecond and sub-nanosecond optical pulses generation in semiconductor lasers, as well as to develop electronic drivers that enable the generation, shaping, and energy measurement of such pulses. The work consists of three main parts: theoretical analysis, numerical simulations, and description of experimental work.

The theoretical considerations focused on analyzing the kinetic equations of the semiconductor laser, which are the fundamental mathematical description of laser dynamics. Based on these equations, steady-state, small-signal, and large-signal analyses were conducted, and the obtained results served as a starting point for interpreting experimental results. The work presented various methods of laser pulse generation, with particular emphasis on direct current modulation and gain switching.

The numerical part presents the results of computer simulations carried out in the MATLAB mathematical environment. Based on the kinetic equations, steady-state and frequency characteristics of the semiconductor laser as well as time-domain optical signal waveforms for given initial conditions were obtained numerically. These results allowed for a comparison of the applied mathematical models. The phase plane method was also presented as an additional tool for analyzing the dynamics of semiconductor laser.

Within the frame of the experimental research, various methods of generating current pulses used for powering semiconductor lasers and enabling the generation of nanosecond and sub-nanosecond pulses were reviewed. Electronic systems were designed and implemented using various phenomena of fast signal switching, including the hazard effect in logical circuits, the avalanche breakdown effect in junction transistors, and the rapid switching of step recovery diodes. The experimental results confirm the possibility of generating short laser pulses using the developed electronic drivers. The shortest optical pulse, with high amplitude (peak power of 38 mW) and a duration of 15 ps, was obtained using the gain switching method.

Next, selected methods of laser pulses shaping aimed at eliminating relaxation oscillations in the semiconductor laser were discussed and experimentally verified. Total elimination of nonlinear dynamic effects was demonstrated by applying the preliminary biasing of the laser diode and the light injection method.

An innovative system for measuring the energy of nanosecond duration laser pulses was also presented, ready to be used in active amplitude control systems or as a standalone measuring device. The system is characterized by high sensitivity, high speed of operation, and small size.

The results obtained during the doctoral research may find applications in fiber optic laser systems, free-space communications, or LIDAR systems.