To simulate mode-lock pulsing in that laser cavity Shrödinger equation in spectral domain is used [1, 2]:

,

where is the pulse spectrum, is the pulse electric field profile, is the pulse spectrum angular frequency deviation from central carrying frequency , z is the coordinate along the fiber, and are the dispersion coefficients at pulse spectrum central wavelenght for fiber with core diameter 9 *µm*, is the nonlinear coefficient, is the Fourier transform of pulse phase self modulation term, is the parameter that defines Tm3+ active fiber parabolic amplification spectrum width, is the gain along the active fiber.

Active fiber amplification spectrum is represent by formula:

.

As result of simultaneous action of pulse group velocity dispersion and self phase modulation pulse gets frequency chirp:

.

Pulse frequency chirp can be represented as wavelength chirp:

,

where is the pulse group velocity.

Active fiber gain saturation is determine by equation:

,

where is the small signal gain, is the gain saturation power, is the resonator round trip time, is the pulse energy.

Pulse profile and spectral intensity is determined consequently:

,

.

Saturable absorber intensity depended loss dynamics is governed by the rate equation:

,

where is the pulse intensity depended loss, is the unsaturable losses, is the absorber recovery time, is the absorber saturation power.

To find pulse time-bandwidth product we evaluated the FWHM of pulse intensity profile and spectral intensity . For Gauss and sech like pulses time-bandwidth product is equal 0.441 and 0.315 consequently.

Filter induced losses determined by super-Gaussian function:

,

where is the filter center wavelength position deviation from active fiber amplification bandwidth center at , and is the parameters that defines filter bandwidth and steepness.

The laser cavity parameters used in simulation is shown in Table 1.

[1] Govind Agrawal,

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(<https://www.sciencedirect.com/science/article/pii/B9780123970237000024>)

[2]