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# Pulse fibre laser with variable configuration of ring resonator supporting radiation polarisation

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***Abstract**: pulse fibre laser with variable configuration of ring resonator supporting radiation polarisation comprises a pumping source, a module of spectral convergence, which signal input is coupled to fibre insulator while its signal output is coupled to the active fibre, which is coupled to fibre brancher by its second end. The insulator and brancher are connected by their second ends to inputs of two fibre-optical switches operated as per 1×N scheme, where N is a number of outputs, at that under control by electronic signals each switch reswitches input optical signals to certain outputs, to which fibre-optical elements are connected thus ensuring active, passive or combined (active-passive) synchronisation of the laser radiating modes or Q-switching of the laser resonator. EFFECT: providing generation of pulses with different pulse length, energy and repletion rates within a wide band.*
*8 cl, 2 dwg*

**Description**

The present invention relates to lasers - devices for generating stimulating radiation using coherent electromagnetic waves.

Of the prior art known fiber laser with a variable configuration of the linear resonator, wherein a main part of the resonator containing the amplifying medium of the laser by a fiber switch connected waveguides with different Bragg gratings that provide lasing at the different wavelengths of radiation (U.S. Patent 7,616,667 B2 , Broadband fiber laser; US patent application 20030128921 A1, Method and device for wavelength switching of a laser source). The disadvantage of this technical solution is that proposed by the cavity does not allow for the generation of radiation in a pulsed mode-locked radiation or Q-switched in any configuration.

The closest to the claimed technical solution is a fiber laser with variable pulse duration, the cavity of which there is a gap, a fiber resonator before and after the break terminated with two fiber connectors, which through the female terminals are connected lengths of optical fiber of various lengths to ensure the generation of the output pulses of different duration ( utility model patent RU 119946, publ. 27.08.2012 city). The disadvantages of this technical solution are:

1. the need to manually connect the fiber segments of different lengths. No possibility of automatic (managed by external electronic signals) switch the laser from one configuration to another;

2. The use of radiation to generate short-pulse mode passive mode locking by using the effect of nonlinear evolution of the polarization of the radiation, which has a relatively high sensitivity to ambient temperature and laying of fiber (bending and twisting changing birefringence fiber, which plays a key role in the manifestation of the effect of nonlinear polarization evolution radiation in the fiber);

3. The use to control the state of polarization of the intracavity light fiber polarization controllers which are "weak" in place of the laser because the polarization controller on the basis of mechanical deformation of the fiber can not usually store the setting for a long time due to plastic deformation fiber, consisting of amorphous silica. This can lead to long-term instability of the laser parameters and overall unreliability of the laser;

4. The limited range of the pulse width of the laser radiation, ranges from a few hundred femtoseconds with a minimum cavity length (several meters) to a few nanoseconds at the maximum cavity length of

25 km (S. Turitsyn, M. Dubov, S. Kobtsev, A. Ivanenko. Mode -locking in 25-km fibre laser. 36th European Conference on Optical Communication (ECOC), Sep 19-23, 2010, Torino, Italy, Tu.5.D.1).

The task to be solved by the claimed invention is to provide a reliable and stable pulsed fiber laser with electronically switchable configurations that support the polarization of the radiation of the cavity, ensuring the generation of pulses with different durations, different energies and different repetition rates in a wide range due to complex applications in a single laser active or passive devices or hybrid (active and passive) of the radiation-locking and Q-switching devices of the laser resonator.

This problem is solved by the fact that, in a pulsed fiber laser with variable configuration supports the polarization of the radiation of a ring resonator containing the pumping radiation source, fiber module of spectral information, the input of the pump is connected to the source of the pump, signal input module of spectral information is connected to the fiber insulator signal output unit of the spectral information is connected to the active fiber, which other end is connected to a fiber coupler, outputting light from the resonator, the inventive fiber isolator and a fiber coupler connected to the other ends of the inputs of the two fiber optic switches operating according to the scheme 1 × N, where N - number of outputs, each switch is under the control of the external electronic signal switches the input optical signals to specific outputs and a pair of outputs of switches attached fiber optics, providing active or passive or hybrid (active and passive) mode locking laser or Q-switching the laser cavity.

Moreover, for active mode locking emission device may be used (optical element) that allows synchronization of radiation modes at frequencies exceeding intermode frequency interval of the laser cavity and multiple intermode frequency interval of the laser resonator. In addition, the length of supporting the polarization of radiation fibers, through which the fiber-optic elements, providing active or passive or hybrid (active and passive) mode locking laser, connected to the pairs of outputs of fiber optic switches can range from 5 m to 25 km .

The technical result provided by the reduced set of features is the creation of a reliable and stable pulsed fiber laser with electronically switchable configuration supports the polarization of radiation of the resonator, which provides generation of pulses with different durations, different energies and different repetition frequency over a wide range: duration of several hundred femtoseconds (providing apparatus passive mode locking based on carbon nanotubes, graphene, topological insulators and other materials) to the second (provided devices Q-based acousto-optic modulators, polarization modulators - for example a Kerr cell or Pockels cell, or turn quickly resonator mirrors or other devices), energy pulses nanojoules of units (with femtosecond pulses) to micro- and millijoules (with a pulse duration of 1 ns), the pulse repetition frequency of 8 kHz up to 20 MHz in active mode locking (8 kHz correspond to the resonator length of 25 km, 20 MHz - length cavity 10 m) at a frequency equal to the intermode frequency range of the laser cavity, and more than 20 MHz (for a harmonic active mode locking, and less than 8 kHz (1 Hz) with a Q-switched laser resonator.

Essence invention is explained following schemes.

1 is a diagram of a pulsed fiber laser with a variable configuration supporting ring resonator polarization of radiation by using two fiber optic switches (6-1 and 6-2), employed in scheme 1 × 2 1 - pumping radiation source, 2 - Fiber Module spectral information of the pump radiation and fiber laser, 3 - optic isolator, 4 - active fiber, 5 - fiber coupler that outputs light from the cavity, 6-1 and 6-2 - Fiber optic switches, 6 ', 6 "- inputs fiber optic switches, 61 '/ 61' and 62 '/ 62 "- a pair of outputs of fiber optic switches, 9 - fiber optic, providing active or passive or hybrid (active and passive) mode locking the laser, 10 - fiber -Optical element that provides Q-switching laser.

2 is a diagram of a pulsed fiber laser with a variable configuration supporting ring resonator polarization of radiation by using two fiber optic switches (6-1 and 6-2), employed in scheme 1 × 4 1 - pumping

radiation source, 2 - Fiber Module spectral information of the pump radiation and fiber laser, 3 - optic isolator, 4 - active fiber, 5 - fiber coupler that outputs light from the cavity, 6-1 and 6-2 - Fiber optic switches, 6 ', 6 "- inputs Fiber optic switches, 61 '/ 61', 62 '/ 62', 63 '/ 63' and 64 '/ 64 "- output pair of fiber optic switches, 7 - the fiber-optical element providing an active mode locking of the laser, 8 - fiber optical element providing passive mode locking of the laser radiation 9 - fiber optical element providing a Q-switching the laser resonator.

The device operates as follows:

pump radiation generated by the source 1, the optical pumping radiation, through the fiber module spectral information 2 enters the active fiber 4, turning the laser active medium in an active state; generation of laser is carried out in a ring resonator, a unidirectional lasing provided an optical isolator 3; the output radiation from the resonator made fiber coupler 5; elektropereklyuchaemyh via fiber optic switches (6-1 and 6-2), employed in scheme 1 × N, where N - number of outputs, to the general part of the laser resonator, comprising the elements 1-5, 6-1 and 6-2, join alternate each output pair 6-1 and 6-2 switches, fiber-optics, providing active or passive or hybrid (active-passive) mode locking laser or Q-switching laser. In order to exclude the effect of the nonlinear evolution of the polarization of radiation and eliminate the use of fiber polarization controllers, all the elements of the laser cavity supports the polarization of radiation. The use of the laser cavity devices (optical elements) that provide different mode locking and Q-switching, allows you to get pulses of different duration, different energies and different repetition frequency of one laser. To increase the range of variation of the energy pulse length supporting the radiation polarization fiber through which optical fiber units are connected to pairs of outputs of the fiber optic switches can be relatively large (from 5 m to 25 km) for increasing the length of the laser cavity, which in the mode of Synchronization modes of radiation reduces the pulse repetition rate and a corresponding increase in pulse energy at the same pump power. (See, for example: S. Kobtsev et al. Ultra-low repetition rate mode-locked fiber laser with high-energy pulses. Optics Express, v.16, №26, 21936-21941 (2008); SM Kobtsev et al. High-energy mode-locked all-fiber laser with ultralong resonator. Laser Physics, v.20, 2, 351-356 (2010) ). Said wavelength band of the radiation polarization supporting the optical fiber (5 m to 25 km) is selected on the basis of the results of experimental studies by the inventors, which revealed that when the resonator length of the optical fibers greater than 25 km lasing becomes unstable.

**Claims** (8)

1: Pulse fiber laser with variable configuration supports the polarization of the radiation of a ring resonator containing a source of pump radiation, fiber module of spectral information, the input of the pump is connected to the source of the pump, signal input module of spectral information connected with a fiber isolator, the signal output unit of the spectral information connected with the active fiber, which other end is connected to a fiber coupler, outputting light from the resonator, characterized in that the fibrous insulator and a fiber coupler connected to the other ends of the inputs of the two driven external electronic signals fiber optic switches operating according to the scheme 1 × N, where N - number outputs, and outputs a pair of switches using light polarization maintaining optical fibers attached fiber optics, providing active or passive or hybrid (active-passive) mode locking laser or Q-switching laser.

2: The laser according to claim 1, characterized in that the active mode locking of the radiation element is used, which provides synchronization of radiation modes at frequencies exceeding intermode frequency interval of the laser cavity and multiple intermode frequency interval of the laser resonator.

3: The laser of claim 1, characterized in that the length of the supporting fibers of the radiation polarization, whereby the optical fiber units, providing active or passive, or hybrid (active and passive) mode locking laser, connected to the pairs of outputs of the fiber-optic switches It is from 5 m to 25 km.

4: The laser of claim 1, characterized in that the element used passive mode locking devices based on carbon nanotubes or graphite or topological insulators or other saturable absorbers of the laser radiation.

5: The laser of claim 1, characterized in that the active element of synchronization modes used device based on acoustooptic or electrooptic modulator or polarization.

6: The laser of claim 1, characterized in that the hybrid cell (active and passive) mode locking laser device is used based on a combination of elements for active and passive modelocking radiation.

7: The laser of claim 1, characterized in that the Q-switching element based on a device used acoustooptic or electrooptic, or polarization modulator or rapidly rotating mirror resonator.

8: The laser of claim 1, characterized in that all the elements of the laser resonator are all-fibre.