Continuously tunable sub-ps pulse train generation using solitonic-effect compression

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Abstract: A simple setup based on semiconductor optical amplifier (SOA) nonlinear dynamics and fiber compression is proposed for the generation of stable sub-ps pulse train. By advantageously using fiber birefringence in combination with a polarization controller and polarizer, the pedestal is significantly eliminated. A train of 935-fs high quality pedestal-free pulses of root mean square (RMS) timing jitter of less than 700 fs is successfully generated. The repetition rate exhibits a continuous tunability in the range from 100 MHz up to 1 GHz and wavelength tunability over the C band. The radio-frequency spectrum analysis method is used for timing jitter measurement.

1. Introduction

Nowadays the laser system that generates high intensity ultrashort pulses is of great importance in the fields of instrumentation and characterization techniques. As an example, the pulsed local oscillator under sampling technique provides a low cost, blind and asynchronous characterization method of high bit rate optical signals, with Tbaud/s potentiality. This technique requires high-quality ps pulse train with repetition rate typically in the 500 MHz to 1 GHz range as a compromise of phase noise impairments and implementation cost. The ultrashort pulse train can also find its application for time-resolved spectroscopy using a pump-probe setup to study fast dynamic processes in materials or chemical compounds.

For generation of ultrashort pulses, passive mode locked lasers are interesting candidates, such as solid-state bulk lasers, fiber lasers and semiconductor lasers [1]. While for mode locked fiber lasers, whose pulse repetition rate is determined by the fiber length, the repetition rate is usually below 100 MHz. Even by employing harmonic mode locking, it tends to be complicated and often do not allow very robust operation. The vertical external-cavity surface-emitting semiconductor lasers (VECSELs) in mode locked operation allows pulse generation of typically a few GHz. Above all, they all suffer from a lack of repetition rate tunability, and semiconductor based lasers also exhibits high phase noise of spectral components [2] that can appear as a bottleneck for application such as asynchronous coherent sampling.

In this paper, we propose a simple setup to generate high power versatile pulse train with ultra wide repetition rate and wavelength tunabilities. It is based on the filtering of the negative nonlinear phase shift induced by the amplification of a rectangular optical signal in a SOA, the solitonic pulse compression and intra-pulse stimulated Raman scattering (ISRS) and high-power induced birefringence. We demonstrate in experiment the generation of 935-fs high quality pulse train of more than 12 dBm average power and less than 700 fs RMS timing jitter. It proves repetition rate tunability from 100 MHz to 1 GHz and may obviously be extended to 1 MHz to few GHz. The pulse train is wavelength tunable over C band thanks to the employing a CW independent optical source that is here a continuous tunable CW laser. In the next part we briefly describe the physical principle and the experimental setup. Then the final generated pulse train is characterized in terms of width, extinction ratio, spectral width and timing jitter.

2. Experimental setup and results

Figure 1 shows a schematic diagram of the experimental setup. It consists of the pulse generation part (A), the pulse compression and pedestal suppression part (B) and pulse characterization part (C). A part generates stable 40 ps pulse train of tunable repetition rate from 1 MHz to few GHz and wavelength tunability in C band [3]. It is based on the optical filtering of the nonlinear frequency components induced by a SOA in which a continuous wave optical signal modulated by NRZ waveform is injected.

The part B consists of two stage of pulse compression and one stage of pulse pedestal suppression. The 1st stage of pulse compression uses 2km Standard Single Mode Fiber (SSMF). The Full Width at Half Maximum (FWHM) of pulse in the train is compressed from 40 ps to 2 ps with pedestal. It is based on the solitonic compression in which the group velocity dispersion plays important role [4].
This stage has also been investigated by simulation that provides good agreement. The 2\textsuperscript{nd} stage of pulse compression uses a SSMF of 500m in which the pulse FWHM is compressed from 2 ps to sub-ps and then pedestal suppressed with a polarization controller and a polarizer. The final generated pulse train is of very small pedestal as measured by an optical autocorrelator, as shown in figure 2 and 3, for different time scale.

The extinction ratio of the autocorrelation trace is measured to be 19.25. Under assumption of a pulse Gaussian time shape the FWHM is 935fs. The spike in the spectrum corresponds to the optical carrier at 1540 nm while the large band of 28.71 nm at -3dB mainly corresponds to the narrow pulse envelope. Furthermore, by employing the technique of radio-frequency spectrum analysis \cite{5} \cite{6}, we measure an average RMS timing jitter of 662 fs over different consecutive measurements.

4. References

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