Multiple-wavelength Signal Generation at 160Gbit/s Using High Nonlinear Fiber

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Multiple-wavelength signal generation from a single colour laser source is attractive for developing high-capacity transmission systems with each channel running at a bit rate of 40 Gbit/s or higher. In this paper, we report a multiple-wavelength signal generation using supercontinuum generation in nonlinear fibers. The performance of the generated multiple wavelength signals is investigated experimentally. The experimental setup is based on a 160Gbit/s OTDM transmitter. The result of the multiple-wavelength signal generation at 160Gbit/s is reported in this paper. The critical issues concerning the supercontinuum generation are discussed.

Introduction

Supercontinuum (SC) refers to the optical spectrum that is continued over a broad range of frequencies. The SC developed from a laser source not only has broadband spectral range, but also has high coherency, high stability and less timing jitter. Recently SC has been demonstrated for its versatility in optical communications. SC generation in optical fibers has been utilized in wavelength conversions[1], multi-wavelength signal generation for dense wavelength division multiplexing (DWDM)[2][3], ultra-short optical pulse generation for optical time division multiplexing (OTDM)[4], optical pulse shaping and all-optical data regeneration[5][6], and multicasting and optical switching in optical networks[7] etc.
Multiple-wavelength signal generation from a signal colour laser is attractive for developing high-speed optical communication systems and networks in a simple and cost effective way. Multiple-wavelength signal generation at 10Gbit/s and 40Gbit/s based on SC for OTDM/WDM transmission has been reported[3][8]. In this paper, we report a two-channel generation at 160Gbit/s at new wavelengths, which together with the original 160Gbit/s pump signal enables us to have a three-channel transmitter with a channel spacing of 3.2 nm. SC generation in high nonlinear fiber (HNLF) and dispersion-shifted fiber (DSF) is performed based on a 160Gbit/s OTDM transmitter.

Experimental setup

To perform the 160Gbit/s SC generation experiments, a seed pulse at the same bit rate is necessary. In the experiments, the seed pulse is obtained from a 160Gbit/s OTDM transmitter as shown in Fig. 1. The transmitter is based on an active mode-locking fiber laser (AMLFL), which produces a 9.95328 GHz, 1.9 ps short optical pulse train. The 9.95328 GHz optical pulse train is modulated by an intensity modulator (IM) driven by an Agilent 70843C pattern generator producing 2^7-1 PRBS sequence at 9.95328 Gbit/s. The modulated data signal is then multiplexed into 160Gbit/s through the OTDM multiplexer (MUX).

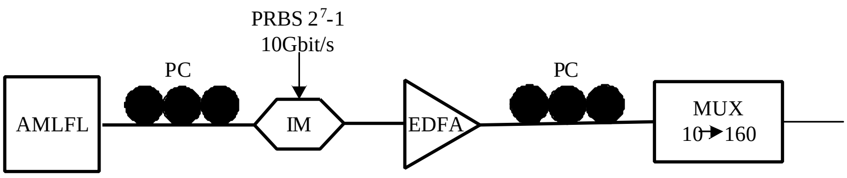


Fig.1. 160Gbit/s OTDM transmitter

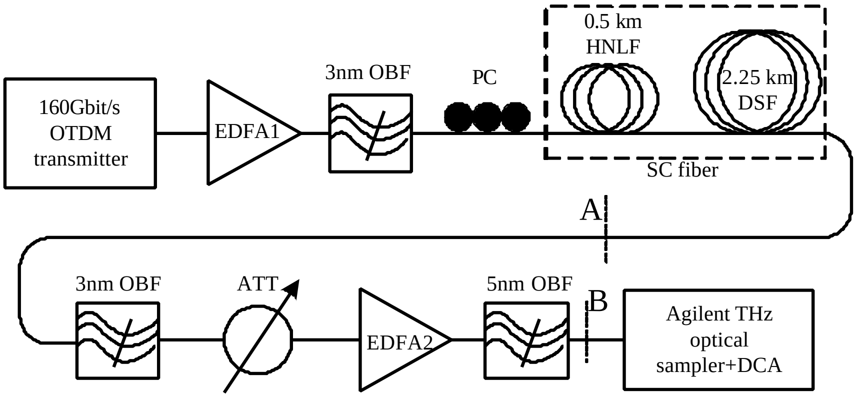
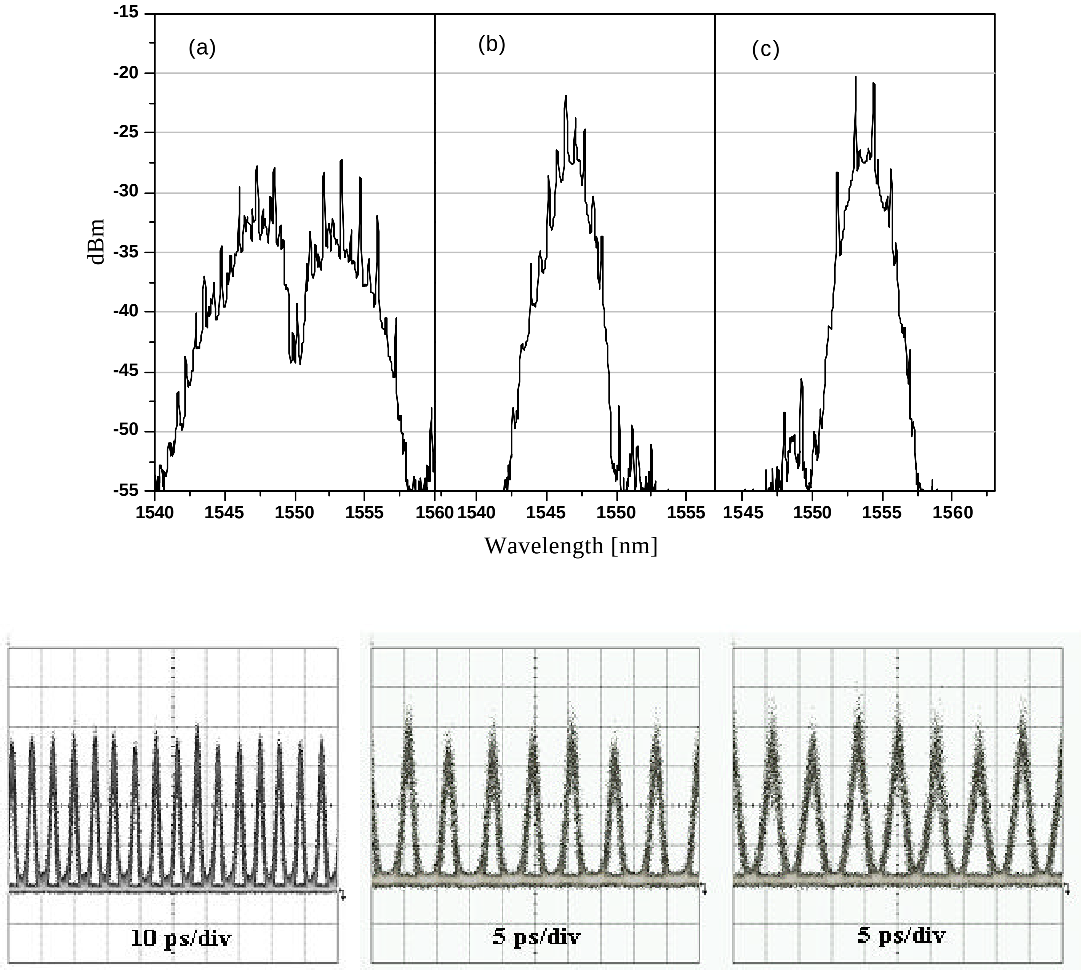


Fig. 2. Experimental setup of the multi-wavelength signal generation at 160Gbit/s

The experimental setup for the multiple-wavelength signal generation based on SC generation is shown in Fig.2. The 160Gbit/s OTDM transmitter produces a 160Gbit/s optical pulse train at 1550 nm that is used as the pump pulse for SC generation. The pump optical pulse is first amplified by an EDFA that can give the maximum output power of 27 dBm, and then enters the SC fiber through a 3 nm optical band-pass filter (OBF) for SC generation. The OBF is important to get a sable and coherent SC pulse signal. The SC fiber comprises a 0.5 km high nonlinear fiber (HNLF) and a 2.25 km dispersion shifted fiber (DSF). The zero dispersion wavelength and dispersion slope of the HNLF are 1545 nm and 0.03 ps/nm/km, respectively. The DSF has a zero dispersion wavelength of 1550 nm and a dispersion slope of 0.075 ps/nm/km. At the output of the SC fiber, a 3 nm tunable OBF is employed to selecting the center wavelength of the SC pulse. In order to measure the quality of the generated 160Gbit/s optical pulse signal, a tunable optical attenuator (ATT) is used to reduce the power level, and an EDFA is set to give a constant output power of 5.8 dBm. A tunable 5 nm OBF is place behind the EDFA2 to reduce the amplified spontaneous emitting (ASE) noise and to shape the spectrum of the generated 160Gbit/s signal pulse. Finally the generated signal pulse enters an Agilent 86169A THz optical sampler and an Agilent 86100B digital communication analyzer (DCA) for eye measurement.

Experimental Results and discussions

In order to generate good quality signals, the optical spectrum of the SC pulse and the spectrum sliced signal pulse are monitored by an optical spectrum analyzer (OSA). During the measurements, we found that with the available SC fiber, it is difficult to get broad and flat SC broadening while obtaining good quality wavelength-converted signal at 160Gbit/s. We have observed that when the output power of the EDFA1 exceeds a certain level, the quality of the pulse degrades.



(d) (e) (f)

Fig.3. Results of multiple-wavelength signal generation at 160Gbit/s based on SC method. (a) the optical spectrum of the pump pulse after the SC fiber measured at position A. (b) the optical spectrum of the generated 160Gbit/s signal at 1546.65 nm measured at position B. (c) the optical spectrum of the generated 160Gbit/s signal at 1553.22 nm measured at position B. (d) eye diagram of the input 160Gbit/s pump pulse. (e) eye diagram of the generated 160Gbit/s signal at 1546.65 nm. (f) eye diagram of the generated 160Gbit/s at 1553.22 nm.

Fig.3 gives the results of a two-channel generation experiment at 160Gbit/s based on SC generation. The output power of EDFA1 is 23.3 dBm in the measurement. Fig.3 (a) shows the optical spectrum of the 160Gbit/s pump pulse measured at position A. The line spectrum structure in the optical spectrum indicates that the SC pulse has good coherence for the wavelengths from 1546 nm to 1556 nm except those near 1550 nm. Decreasing the output power of EDFA1 can eliminate the dip in the center, however the spectrum is less broadening. Figs.3 (b) and (c) are the optical spectra of the generated 160Gbit/s signals at 1546.65 nm and 1553.22 nm, respectively. Figs. 3 (d), (e) and (f) are the measured eye diagrams of the 160Gbit/s input pump pulse, the generated 160Gbit/s signal pulse at 1546.65 nm, and the generated 160Gbit/s signal pulse at 1553.22nm, respectively. The measured Q factors are 6.2 and 6.4 for the generated signals at 1546.65 nm and 1553.22 nm respectively. From the eye diagrams of the generated 160Gbit/s signals, we see the pulse width of the signal at 1553.22 nm is larger than that of the signal at 1546.65 nm. We observed that the timing jitter performance of the generated signal is comparable with that of the input pump pulse. However the converted signal pulses have greater intensity noise on the "1"s.

Conclusions

We have reported a 2-wavelength signal generation at 160Gbit/s based on SC generation in a SC fiber comprising a 0.5 km HNLF and a 2.25km DSF. The generated signals have good eye opening giving Q factors larger than 6.0. The two channels together with the original pump signal enable us to get a three-channel WDM transmitter with a channel spacing of 3.2 nm.

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