Short Communication

Chromatic Dispersion Compensation in 80Gbps Ultra High Bit Rate Long-Haul Transmission with Travelling Wave Semiconductor Optical Amplifier

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Received 19 December 2016; revised 17 October 2017; accepted 11 January 2018

This paper proposes a novel dispersion compensation method using Optical Phase Conjugation (OPC) method with travelling wave Semiconductor Optical Amplifier (SOA) at a data rate of 80Gbps. This method can replace the large optical filters in the existing method using Fiber Bragg Grating (FBG). The performances are measured in terms of critical parameters like OSNR, FWM conversion efficiency, output optical power and output electrical power. Results show that our method can improve the optical power about 18dB from existing method. This proposed method can increases the OSNR about 38dB and RF power about 15dB from the existing method. The conversion efficiency can also be improved about 3dB from the existing method.

Keywords: Optical Phase Conjugation, Four Wave Mixing, SOA, Single Mode Fiber

Introduction

Chromatic dispersion in the fiber limits the transmission distance of optical systems. Dispersion resistant modulation formats are used for reducing the dispersion 1. A mid-span spectral inversion (MSSI) technique has been recently used for the dispersion compensation in metro networks2. In the MSSI technique, the dispersion compensation is by placing an Optical Phase Conjugator (OPC) at the middle of a complete transmission link. That inverts the spectrum and the phase of optical signals distorted by the chromatic dispersion3. Cost-effective transmission systems can be possible by using Semiconductor Optical amplifiers (SOA) instead of erbium-doped fiber amplifiers as in-line amplifiers4. The structure of SOA is like semiconductor laser but it has no resonant cavity5. Dispersion Shifted Fiber (DSF) and SOA are the most promising methods for optical phase conjugation and wavelength conversion using FWM6. The efficiency has been increased by using both new fibers7 and SOAs8. A semiconductor-optical-amplifier-based technique is used to generate the conjugate of an optical signal9. FWM supports high bit rate and conserves phase and amplitude information. FWM is the only method with transparent optical properties in the conversion process occurring within the SOA10. The efficiency of the wavelength converter decreases with increasing detuning of frequency. The conversion efficiency of FWM depends on various factors like pump frequency, signal frequency and the size of the active region of the SOA. Increasing the gain, saturation power and carrier recovery rate of an SOA are a few practical methods of improving the conversion efficiency of an FWM wavelength converter11. In this paper, we have proposed a novel chromatic dispersion reduction method using optical phase conjugator configuration with inline travelling wave SOA in 80 Gbit/s system experiments. The large optical filters used in the existing method12 are replaced by FBGs. This proposed method uses FBGs to filter the phase conjugated signal and to reduce ASE noise. This method can increase OSNR, optical power and electrical output power of existing methods. Also, this method can transmit an 80Gbps data through a 400km fiber with sufficient OSNR, which is higher than the existing methods. The rest of the paper is organized as follows. Section II explains about the experimental setup of the system. Section III deals with results and discussion. Finally, section IV concludes the paper.

Experimental Set Up

The system performance is presented through visualizing tools, such as optical spectrum analyzer, RF spectrum analyzer, and electrical carrier visualizer, which are used to display the spectrum at the output of the circuit components. Table 1 shows the global parameters of the components in the setup. Figure 1 shows an 80Gbps externally modulated RoF transmission using single Electrode Mach–Zehnder Modulator. A user defined random sequence is used to modulate the MZM.

A single electrode MZM with an extinction ratio of 30dB. The result of the intensity modulation is an Optical carrier with a Double-Sideband (ODSB)
transmission externally modulates a tunable external cavity pump laser (laser 1 with 1541 nm). The optical spectrum is spread over a wide range of frequencies that affects the quality of the signal when it is transmitted over the optical fiber link. The optical link is split into two. After the first half of the fiber, the signal is dispersed. The spectral inversion is formed by using a coupler, travelling wave SOA and ideal dispersion compensation FBG. The second input of coupler is a continuous laser with 1540 nm. When the dispersed signal is fed through the spectral inverter, the signal is phase conjugated. The combined signals are passed through a travelling wave SOA of injection current 0.15 A to generate the phase-converted spectrum. The phase conjugated signal is filtered using an ideal dispersion compensated FBG at 1539 nm and dispersion, \(D = 800 \text{ps/nm} \). The filtered signal is amplified by an erbium doped fiber amplifier (EDFA) with a length of 5 m. The EDFA is used to improve the combined signal power and to saturate the SOA. A 125 GHz bandwidth ideal FBG is used just after the EDFA to reduce additional ASE outside the signal bandwidth. Therefore, the OSNR of the converted signal is increased. This signal is passed through the second half of the fiber and the dispersion is compensated. The signal is obtained at the receiver by using a PIN Photodiode with a responsivity of 1 A/w and a dark current of 10 nA.

**Results and Discussion**

Figure 2 (a) shows the optical power of both proposed method (pd) and existing method (eg). Graphs show that the proposed method can increase the output power about 18 dB from the existing method. Figure 2 (b) shows the OSNR of the proposed method (pd) and existing method (eg). Graphs show that our method can improve the OSNR about 38 dB from the existing method.

**Table 1 — Global parameters and their values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value Description</th>
<th>Parameter</th>
<th>Value Description</th>
<th>Parameter</th>
<th>Value Description</th>
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<tbody>
<tr>
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<td>SMF Parameter</td>
<td>Value</td>
<td>Photo detector Parameter</td>
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<td>CW laser (pump)</td>
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<td>MZM Extinction ratio</td>
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</table>

**Fig. 1 — Block diagram of optical phase conjugation using travelling wave SOA**

**Fig. 2 — a) Optical output power of the existing method (eg) and proposed method (pd), (b) OSNR of the converted signal using proposed method (pd) and existing method (eg)**

**Table 1 — Global parameters and their values**
Graphs show that efficiency of proposed method is improved about 3dB from the existing method.

Conclusion

We are demonstrated a novel chromatic dispersion compensation method using FWM technique of traveling wave SOA. Its performances are compared with the existing method in terms of output optical power, OSNR, conversion efficiency and output electrical power. The results show that our method can improve the performance of existing method. It can also transmit the higher data rate of 80Gbps to a longer transmission distance of 400Km, which is higher than the existing methods. Therefore, this high efficient configuration can give better results in future optical transmission systems. This configuration has shown good performance over the conventional externally modulated system.

Reference