Investigation of SOA-based wavelength conversion at 80 Gb/s using bandpass filtering

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Abstract: This paper presents a simple and effective 80 Gb/s wavelength conversion scheme by using Cross Gain Modulation in a Semiconductor Optical Amplifiers (SOA) in conjunction with filtering the blue shifted component of the probe spectrum to give a non-inverted output signal.

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1. Introduction

Conventional Semiconductor Optical Amplifiers (SOAs) have a gain recombination time of approximately 90 ps which limits traditional wavelength conversion schemes to a max bit rate of 10 Gb/s. Liu et al. achieved a 160 Gb/s wavelength conversion thanks to a scheme based on phase-amplitude coupling in an SOA and a shifted filtering [1]. However without adding an interferometric configuration the extinction ratio (ER) is not sufficient and the output data are inverted. Similar techniques based on cross gain modulation (XGM) in SOA and shifted filtering have also been proposed and those enable non-inverted wavelength conversion at 40 Gb/s [2] [3]. In this paper, we have implemented a 80 Gb/s wavelength conversion thanks to this technique using a correctly positioned spectral filtering XGM and give some highlights of the limitations of the use of this technique at higher bit rates.

2. Principle:

The principle of the technique is based on spectral broadening and shifted filtering as it has been first proposed by Mamyshev et al.[4]. In our work, the spectral broadening is obtained by XGM through the process of phase-gain coupling on the probe signal in the SOA. Then, a filter selects the blue-shifted sideband of the probe, converting phase modulation into amplitude modulation, while efficiently suppressing the CW carrier wavelength. Suppressing the carrier corresponds to suppressing the DC content of the polarity inverted probe waveform; thus, the data pump polarity is preserved. Moreover, this technique works thanks to the fast transition time of the blue-shifted probe spectrum due to carrier heating process in comparison with the interband gain recovery time [5].

3. Experiment

The experimental setup is presented in Fig. 1. The pump signal was a 40 GHz mode-locked fibre laser (Calmar Optcom) which generated 2 ps pulses at 1555 nm. This signal was modulated with a PRBS 2^{15}-1 data at 40 Gb/s by a $LiNbO_3$ electro-optic modulator. The 40 Gb/s pulse train was multiplexed to 80 Gb/s using a fibre based multiplexer. The continuous probe was generated by a DFB laser at 1545 nm. The pump and probe signal were coupled and injected into the SOA with an average power of 3 dBm and 5 dBm respectively.

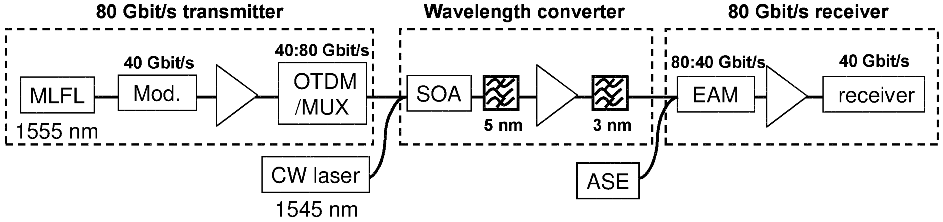

Fig. 1: Experimental setup of wavelength conversion at 80 Gb/s

The SOA was 1.2 mm long with a gain recovery time of 90 ps and had an applied bias current of 250 mA. At the output of the SOA a filter with a 3 dB bandwidth of 5 nm and a sharp band edge was used to reject the output pump signal and to significantly reduce the continuous wave portion of the probe which in turn improves the ER of the wavelength converted pulses. An EDFA is used to compensate for the loss of the probe signal to ensure a good OSNR. A second filter of 3nm is then used to precisely select the spectrally broadened part of the probe spectrum. The filter shift of 2.4 nm is correctly chosen to have a non-inverted signal at the output with no pattern effects. After

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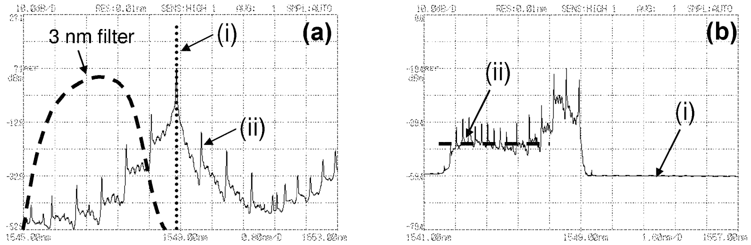
wavelength conversion, an EAM driven with 40 GHz local clock was used to optically demultiplex down to 40 Gb/s. To enable the measurement of the BER evolution as a function of the OSNR signal an Amplified Spontaneous Emission (ASE) source was added to the system to degrade the 80 Gb/s OSNR signal.

4. Results and discussion

Fig. 2(a) displays the probe spectra directly after the SOA, without (dotted line) and with (solid line) pump modulation, as well as the 3 nm filter shilfted by 2.4 nm. Fig. 2(b) shows the spectrum before the 3 nm filter and from this we can clearly see that the OSNR of the wavelength converted signal is essentially limited by the ASE of the SOA. Fig. 3 shows BER versus OSNR of both 40 Gbit/s DEMUX tributaries, for the reference signal (3-i), and for the probe signal (3-ii). The low level of probe OSNR (23 dB in 2 nm bandwidth) explains in part the 5dB penalties measured on the wavelength converted signal (reference signal OSNR measured of 33 dB in a 2 nm bandwidth). This BER measurement proves the ability to carry out wavelength conversion at 80 Gbit/s with an SOA that has a gain recovery time as long as 90ps.

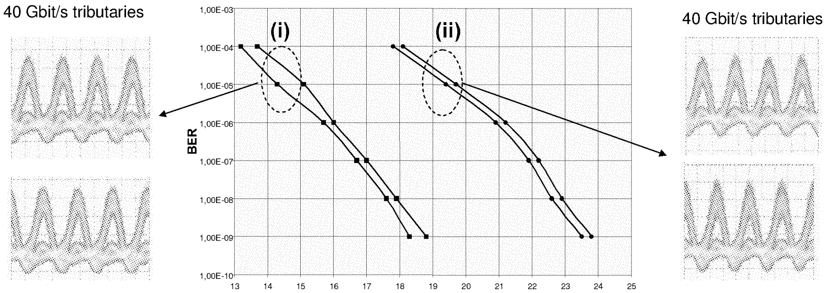


(i) Without pump modulation
(ii) With pump modulation

(i) EDFA noise level
(ii) SOA noise level

Fig. 2: a) probe spectrum at the SOA output; (b) probe spectrum before 3nm filter

Notice that at 40 Gb/s we measured a penalty of 1.5 dB similar to [2], but this increases to 5 dB at 80 Gb/s. As explained previously, the penalties are due to the low OSNR of probe signal at the SOA output and are not primarily due to the noise of the EDFA as suggested in [2].



(i) Two tributaries of Reference signal
(ii) Two tributaries of wavelength converted signal

Fig. 3: BER evolution as a function of OSNR measured in 2nm bandwidth

5. Conclusion

This paper has presented a simple and effective technique to implement wavelength conversion using XGM and shifted filtering to obtain error free results at 80 Gb/s. The long gain recovery time of the SOA was overcome by taking advantage of the fast phase response which was converted into an amplitude response through the shifted position of the filter. Finally we detail how the ASE of the SOA is the main limitation of this scheme.

6. References

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