All-optical 2R regeneration and wavelength conversion at 10Gb/s using a single bistable DFB laser diode

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Abstract: We report on optical 2R regeneration and wavelength conversion at 10 Gb/s using a single bistable DFB laser diode.

Keywords: DFB, 2R regeneration, wavelength conversion.

1. Introduction

All-optical signal regeneration and wavelength conversion play a crucial role in increasing transmission distances and reducing blocking probability in WDM network nodes in next generation networks [1].

In this paper we show numerically that wavelength conversion and optical regeneration comprising of enhancement of extinction ratio (ER) and signal reamplification (2R) can be achieved at 10 Gb/s using an AR-coated λ/4-shifted DFB laser diode which is biased above threshold.

Previously [2,3], we have shown that a robust AOFF can be obtained from an AR-coated, λ/4-shifted DFB laser in which a CW beam is injected. It has been demonstrated that a bistability for a certain range of the CW beam originates from spatial hole burning and that the wavelength of the CW beam as well as the pulses used for switching can be relatively arbitrary as long as it is not too close to the lasing wavelength of the laser.

By setting the '0'-level of the signal at the left side of the bistability region, we have investigated numerically that also optical regeneration and wavelength conversion can be achieved at 10Gb/s.

The simulations were done using the commercial software package VPI componentmaker (©, [4]).

2. Operation principle

The simulation setup used to demonstrate 2R regeneration and wavelength conversion is shown in figure 1.

10Gb/s non-return-to-zero (NRZ) signals are generated using a pseudo random bit sequence (PRBS) generator, such that the '0' level is set at the left side of the bistability region of the DFB laser. The signal to noise ratio of this signal is then controlled by a succession of a variable optical attenuator and an EDFA.

The signal then passes through the device and an optical band pass filter is used to obtain the signal at the laser wavelength and the input signal wavelength.

With an optical band-pass filter, we obtain the signal at the two different wavelengths and the signal power that arrives at the receiver is adjusted by a variable optical attenuator. This is useful in plotting the BER vs received power plots.

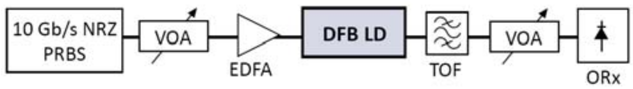
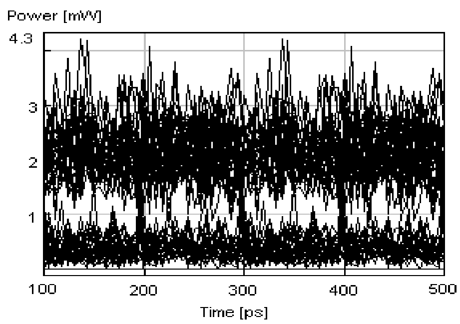


Figure 1: Simulation setup used for the 2R-regeneration and wavelength conversion simulations. VOA: variable optical attenuator; EDFA: erbium doped fiber amplifier; TOF: tunable optical filter; ORx: optical receiver.

3. 2R Regeneration

For 2R regeneration, we use a DFB laser with normalized coupling coefficient κL of 1.8, a length of 400 µm and a differential gain of 5 10^{-20} m^2. The drive current of the laser is 130 mA. Figure 2 shows eye diagrams for the 10 Gb/s back-to-back NRZ signal and for the output signal after the DFB laser. The wavelength of the signal is 1560 nm. The extinction ratio has improved from 7.5 dB to 10 dB. More importantly, there is a very clear and significant noise reduction on both the '0's and the '1's. Figure 3 shows the BER for the input and output signals. We see almost the same sensitivity for a BER value of 10^{-9}.



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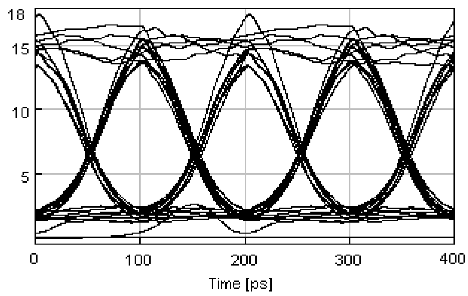

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Figure 2: a) Eye diagram of a 10Gbit/s NRZ back to back signal with ER of 7.5dB. b) Eye diagram of the regenerated output signal with ER of 10 dB.

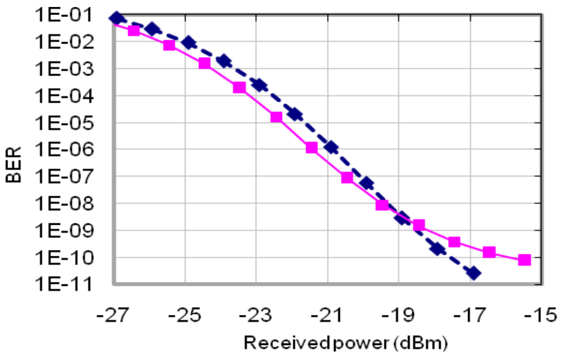
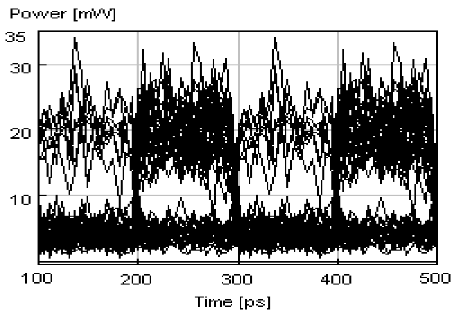


Figure 3 : BER as a function of the signal power incident on the receiver (dashed line is for the back to back signal and solid line is for regenerated output signal.

4. Wavelength Conversion

For wavelength conversion simulations, the parameters used for the DFB laser are the same as before, but now we vary the differential gain between 5 10^{-20} m^2 and 6 10^{-20} m^2. The drive current used for the laser is 240mA. The wavelength converted laser output signal has a wavelength of 1569nm while the input signal wavelength is 1560nm. This device is well suited for wavelength conversion as the input signal wavelength can be relatively arbitrary as long as it is not very close to the lasing wavelength of the laser. Figure 4 shows eye diagrams for the 10Gb/s back to back NRZ signal and for the wavelength converted laser output signal. The input extinction ratio is 6.5dB and the output signal ER is 18dB. This results in an extinction ratio improvement of 11.5 dB. This is, however, accompanied by around 3.5dB power penalty in the receiver sensitivity as



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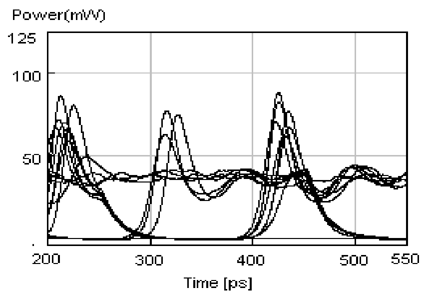

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Figure 4: a) Eye diagram of a 10Gbit/s NRZ back to back signal with ER of 6.5dB. b) Eye diagram of the output signal after passage through the device with ER of 18 dB.

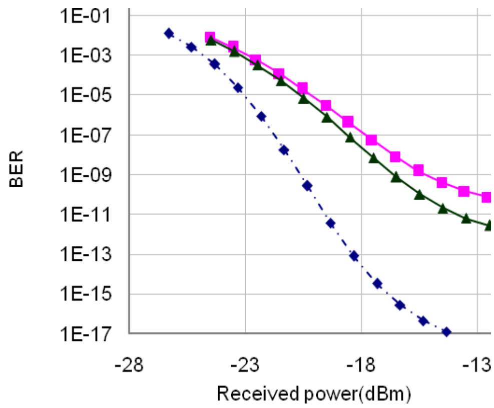

Figure 5 : BER as a function of the signal power incident on the receiver (dashed line is for the back to back signal and the others are for the wavelength converted laser output signal (triangles are for *dg/dN* = 6 10^{-20} m^2 and squares for *dg/dN*=5 10^{-20} m^2).

shown in the BER plots in Figure 5 for the back to back and wavelength converted signals. Better receiver sensitivities have been obtained for relatively larger differential gain values. A clear noise reduction can again be observed from the eye diagrams.

5. Conclusion

We have numerically demonstrated that both optical signal regeneration and wavelength conversion at 10 Gb/s can be performed with a single DFB laser diode. For optical 2R regeneration, a clear noise reduction together with an extinction ratio improvement have been obtained. Wavelength conversion has also been shown to exhibit an extinction ratio improvement of 11.5dB albeit with around 3.5dB power penalty in the receiver sensitivity. Eye diagrams show a clear noise reduction in the wavelength conversion as well. Higher differential gain values show better sensitivity results.

6. Aknowledgment

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7. References

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