Multi-format all-optical 40 Gb/s regeneration using an integrated SOA-MZI

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Optical regenerators capable of handling both on-off keying (OOK) and differential phase-shift keying (DPSK) optical signals are foreseen as key-elements for future optical networking, where new, bandwidth-efficient modulation formats will co-exist with conventional OOK in different parts of the network. In this paper, we show regeneration of 40Gb/s DPSK and OOK signals using a single, multi-functional, integrated semiconductor optical amplifier-based Mach-Zehnder Interferometer (SOA-MZI).

Fig. 1 illustrates the experimental setup used for DPSK regeneration. A mode-locked-laser (MLL) generated a 40 GHz optical clock, which was introduced to a phase modulator (PM) in order to form DPSK data. A cascade of two additional modulators was used to degrade signal quality by applying perturbative amplitude and phase modulation. The degraded signal entered the regeneration unit and was first decoded into 2 complementary OOK bit sequences by an integrated 1-bit delay interferometer (DI). The DI outputs were used as control signals for an integrated twin SOA-MZI so that data information was optically re-encoded on the input CW signal [1]. The SOA-MZI had 10ps unsaturated SOA recovery time and was operated in push-pull configuration in order to further reduce the switching window. Evaluation of the output DPSK signal was achieved after DI decoding and optical demultiplexing of the decoded signals to 10Gb/s. A modified setup was used for OOK regeneration. The optical clock was OOK modulated and was degraded in a second intensity modulator before entering the SOA-MZI. The resultant OOK signal was demultiplexed to10Gb/s and the Bit-Error-Rate performance of the tributary channels was evaluated.

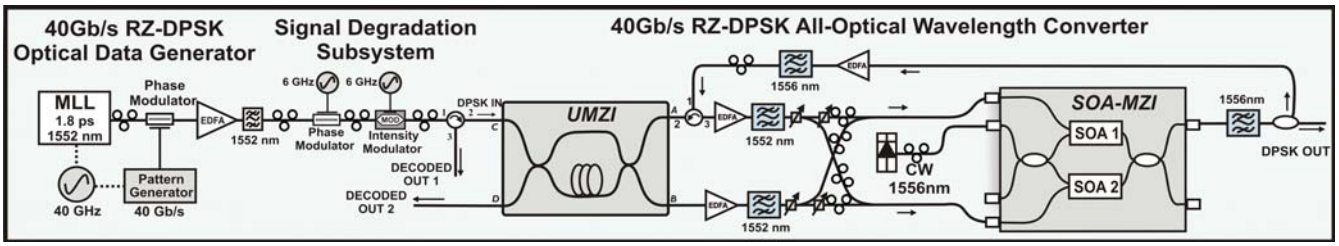

Figure 1: Experimental setup

Fig. 2 shows experimental results for DPSK (left) and OOK operation (right column). Fig. 2(a) and (b) illustrate the decoded channels of the degraded input and regenerated DPSK signal, respectively. Eye-opening improvement was obtained as a result of the lower amplitude and phase noise of the regenerated compared to the input DPSK signal due to the transfer function of the MZI arrangement and the saturation effect of the SOAs [2]. Fig. 2(c) depicts the respective BER curves for the best and worst 10Gb/s demultiplexed channels of the input (BtB), degraded input and regenerated DPSK signals revealing negative power penalty in excess of 1 dB. Similarly, Fig. 2(d) and (e) illustrate the degraded input and output OOK signals respectively. Eye-opening improvement is again observed as a result of amplitude noise suppression in the regenerator. Figure 2(f) shows the BER of the 10Gb/s tributaries of the input and output signals, revealing again negative power penalty.

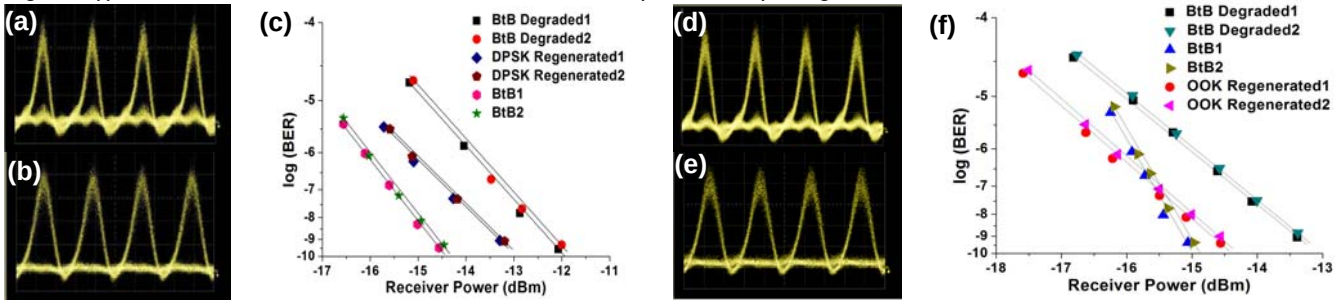

Figure2. Experimental results: (a) degraded DPSK input, (b) regenerated PSK signal, (c) BER curves for best and worst 10Gb/s demultiplexed channels of input, degraded input and regenerated DPSK signals, (d) degraded OOK input, (e) regenerated OOK signal, (f) BER curves for best and worst 10Gb/s demultiplexed channels of input, degraded input and regenerated OOK signals.

In conclusion, multi-format operation of an integrated SOA-MZI has been presented by demonstrating all-optical regeneration of both DPSK- and OOK-encoded signals at 40 Gb/s. Negative power penalty in excess of 1 dB has been shown. Future work involves the integration of the entire multi-format regenerator subsystem on a single photonic chip through hybrid integration.

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[2] P. Vorreau et al., "*Cascadeability and Regenerative Properties of SOA All-Optical DPSK Wavelength Converters,*" IEEE Photon. Technol. Lett., **18**, p. 1970, 2006.