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Clock recovery for 320 Gb/s OTDM data using filtering-assisted XPM in an SOA

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Introduction. In ultra-high speed optical time division multiplexed systems (OTDM) reaching for bit rates of 640 Gb/s with single wavelength and single polarisation, e.g. [1], a key functionality is pre-scaled clock recovery. In this paper, we report on a novel technique, which enables clock recovery at 320 Gb/s and relies on a filtering-assisted cross-phase modulation (f-a XPM) in a semiconductor optical amplifier (SOA). This technique is more spectrally efficient than four wave mixing (FWM) [2], and can improve the efficiency of the error signal generation.

Experimental procedure and results. Figure 1 shows the experimental set-up. An OTDM transmitter emits 1.3 ps wide data pulses multiplexed from 10 Gb/s to bit rates of 40, 80, 160 or 320 Gb/s (2^7-1 PRBS).

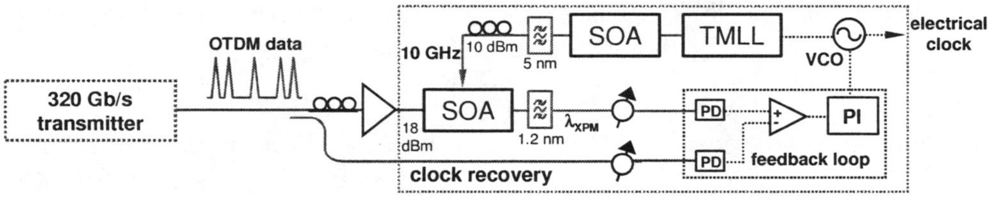

Figure 1. Experimental set-up.

The clock recovery unit consists of a phase-locked loop (PLL) with an all-optical phase comparator part., in which the temporal phase of the incoming data signal is compared to that of a local optical clock consisting of a voltage controlled oscillator (VCO) driven tuneable mode-locked laser (TMLL) producing narrow pulses (2.2 ps) at a ~10 GHz repetition rate. The TMLL pulses are amplified to 10 dBm in a booster SOA before injection into the f-a XPM SOA together with the data signal. Only when a clock pulse coincides with a data pulse will an f-a XPM effect be seen and this temporal alignment dependence is used to generate an error signal for the PLL to lock to [2].

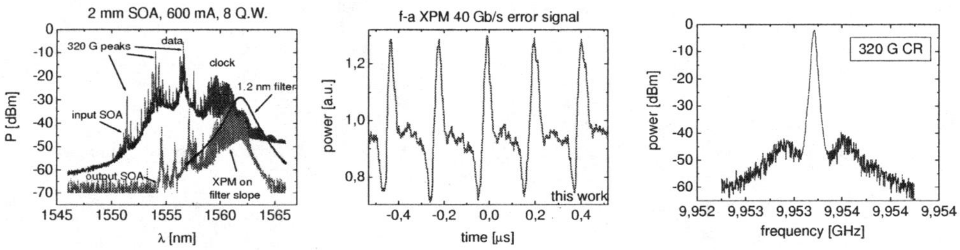

Figure 2. Experimental results. Left: f-a XPM spectra. Middle: Generated error signal for the 40 Gb/s data case. Right: Electrical power spectra of the VCO when locked to a 320 Gb/s data signal.

Figure 2, left, shows the optical spectra of the data (1555 nm) and the clock (1560 nm) at the input to the SOA together with the filtered output and the filter function. The clock and data spectra slightly overlap, thus reducing the required bandwidth. The filter is 1.2 nm wide FWHM and is placed with its slope on the clock spectrum, thus turning a phase modulation into an intensity modulation. This XPM-effect relies on ultra-fast phenomena in the SOA and can thus resolve the 320 Gb/s data when sufficiently short clock pulses are used. Figure 2, middle, shows the generated error signal in the case of a 40 Gb/s data signal, and reveals how a sharp *dispersion shaped* curve may be obtained by placing the filter appropriately. Clock recovery is successfully obtained for rates up to 320 Gb/s, as shown in figure 2, right in terms of the electrical power spectrum of the recovered VCO clock when locked to the data. The carrier peak is sharp with sideband phase noise suppression of about 50 dB, corresponding to a timing jitter of about 800 fs.

Conclusion. In this paper we presented a novel scheme to obtain clock recovery of ultra-high speed data signals. The scheme was verified at bit rates up to 320 Gb/s, and relies on filtering-assisted XPM in an SOA.

References.

[1] J. Seoane et al, Proceedings of ECOC 2004, Stockholm Sweden, paper We1.5.4, 2004. and references therein
[2] L.K. Oxenløwe et al, Proceedings of ECOC 2004, Stockholm Sweden, paper We3.5.2, 2004 and references therein.

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