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Simultaneous Add-Drop Multiplexing of 80 Gbit/s Data in a Non-Linear Optical Loop Mirror

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Abstract *We report on a demonstration of simultaneous 80 Gbit/s add-drop multiplexing in a non-linear optical loop mirror. Data pulses are actively dropped and added via cross-phase modulation by the same control pulse.*

Introduction

Add-drop multiplexing (ADM) is an important functionality in Optical Time-Division Multiplexed (OTDM) systems, in which several low bit-rate data-channels at identical wavelengths are bit-interleaved to obtain a high bit-rate data signal for transmission. ADM is the operation where one channel is extracted (dropped) from the aggregate signal and a new low bit-rate channel is added in the vacant time-slot (added channel). This functionality is a requirement for the realisation of network nodes in OTDM systems. ADM switches have been realised using both semiconductor components [1,2] and Highly Non-Linear Fibre (HNLF) [3,4,5]. In [1-5], the drop-channel is extracted actively through a nonlinear optical process, while the added channel is passively coupled to the aggregate data signal after the drop operation.

In this paper, we present an experiment where both the add- and drop-operations are performed actively in a Non-Linear Optical Loop Mirror (NOLM). They occur simultaneously via the same switching window, created by high-intensity control pulses through cross-phase modulation (XPM).

Principle

The principle of the Simultaneous Add-Drop Multiplexer (sADM) based on a NOLM is shown in Figure 1. The internal polarisation control is adjusted so that input signals are reflected by the NOLM, fulfilled for both the 80 Gbit/s OTDM signal as well as the 10 Gbit/s add-channel (both are at λ_{data} = 1557 nm). Circulators redirect the reflected signals towards the 80G-out and drop ports, respectively. High-intensity control pulses at 10 GHz (λ_{ctrl} = 1543 nm) are then coupled into the NOLM. Time delays ensure synchronisation inside the HNLF between the 10 Gbit/s drop-channel (black pulse in the 80 Gbit/s input signal), the 10 Gbit/s add-channel (dashed pulse) and the 10 GHz control pulses. The external polarisation controllers and the control pulse power are adjusted so that the add- and drop-channels experience a phase-shift through XPM by the control pulses. This causes them to be transmitted by the NOLM instead of being reflected. As a result, the drop-channel is switched out at the drop port, and the add-channel is

switched into the 80 Gbit/s signal at the original position of the drop-channel, both operations being performed simultaneously. The control pulses are suppressed at the output ports by optical bandpass filters (BPF).
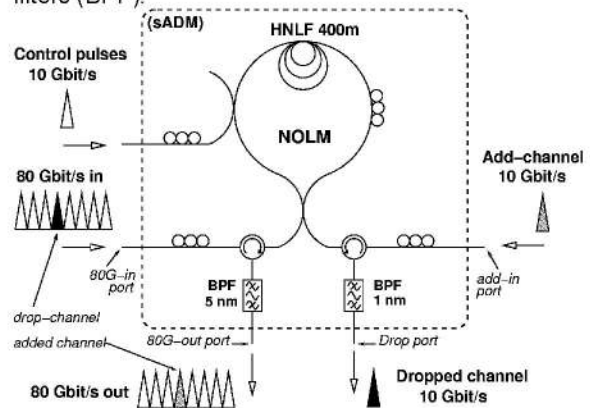

Figure 1: Simultaneous Add-Drop Multiplexer (sADM) at 80 Gbit/s, using a NOLM.

Experimental set-up

The experimental set-up is shown in Figure 2. It contains two pulse sources: a 10 Gbit/s transmitter and a 10 GHz semiconductor tunable mode-locked laser (TMLL, λ_{ctrl} = 1543 nm). The transmitter is composed of a 10 GHz Erbium Glass Oscillator Pulse Generating Laser (ERGO PGL, λ_{data} = 1557 nm), followed by a Mach-Zender modulator which intensity-modulates the pulses with a 2^7-1 PRBS data pattern. A 10 GHz synthesizer synchronises the transmitter, the TMLL, and the 10 Gbit/s receiver. The 10 Gbit/s data is split in two by a 3 dB coupler. The first output is multiplexed up to 80 Gbit/s by a passive delay-line
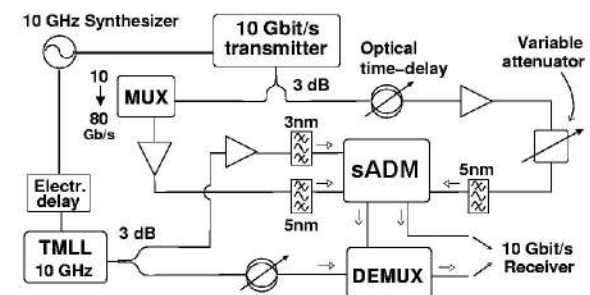

Figure 2: Experimental set-up.

multiplexer (MUX), amplified, filtered by a 5 nm BPF, and then directed to the 80G-in port of the sADM (see Figure 1). The HNLF is 400 m long, with a nonlinear coefficient of 10.5 $W^{-1} \cdot km^{-1}$, a dispersion of -1.20 $ps \cdot nm^{-1} \cdot km^{-1}$ and a slope of 0.003 $ps \cdot nm^{-2} \cdot km^{-1}$ at 1550 nm. The second output of the 3 dB coupler is directed to the add-in port, via a variable optical time-delay, an EDFA and a variable attenuator, used to optimise the position in time and amplitude of the added channel. The control pulses are obtained from the TMLL via a 3 dB coupler, and then amplified and BPF-filtered (3 nm) before entering the NOLM. Their timing is adjusted by the electrical time-delay. This, and the optical delay before the add-in port, ensure that the control pulses, the drop-channel of the 80 Gbit/s input, and the add-channel overlap inside the HNLF. The average input powers and pulse widths (FWHM) at the sADM are: 4.4 dBm and 1.8 ps for the 80 Gbit/s pulses, -3.8 dBm and 1.8 ps for the add pulses, and 22.4 dBm and 2.0 ps for the control pulses. The dropped channel is directly injected into the receiver. In order to evaluate the 80 Gbit/s output signal, it is directed into an additional NOLM (DEMUX) for demultiplexing to 10 Gbit/s before detection in the 10 Gbit/s receiver. The control pulses for DEMUX are also obtained from the TMLL. A variable optical time delay on the control pulses before DEMUX allows for demultiplexing each channel in the 80 Gbit/s out data.

Results

Eye diagrams are shown in Figure 3 (a)-(d). A BER measurement of the dropped channel is performed in two cases: with add pulses on and off. The respective BER curves appear in Figure 3, upper left. The penalty is 2.8 dB and originates primarily from interferometric cross-talk between the drop pulse and remaining, non-switched (i.e. reflected) add-pulse light. The 80 Gbit/s output data are demultiplexed, and the sensitivities are measured for each channel (triangles in Figure 3, lower left). These are compared to the case where the control- and add-pulse inputs to the sADM are off, and the 80 Gbit/s input is simply reflected by the sADM towards the DEMUX (through channels, squares). The added channel (no. 4) has suffered a 2.4 dB penalty compared to the case of no add-drop operation (the two BER curves appear in Figure 3, upper left). The penalties for the other channels range from 0 to 1.3 dB.

Discussion

The 10 GHz control pulses induce a common switching window for both add- and drop pulses. This window limits the placement of the add-channel in the 80 Gbit/s sADM output data, the accuracy (window-width) depending on the pulse widths and amount of walk-off between control and data pulses in the HNLF. Furthermore, the polarisation state of the

added channel should match that of the original drop-channel. We expect that this condition may be satisfied since the polarisation states of the drop- and add-channels are optimised to the same control pulse polarisation-state, to give the same XPM-induced phase shift. In order to lower the measured penalties, higher switching extinction ratio (~17 dB in this case) as well as lower control pulse timing jitter are necessary. This will reduce the interferometric cross-talk between the added/dropped pulses and overlapping non-switched drop/add pulse light. Note that control pulse timing jitter is transferred onto both switched and non-switched light as intensity noise. The RMS control pulse timing jitter was ~500 fs, which also limits this set-up to 80 Gbit/s operation. The actual switching mechanism would allow for much higher bit rates.
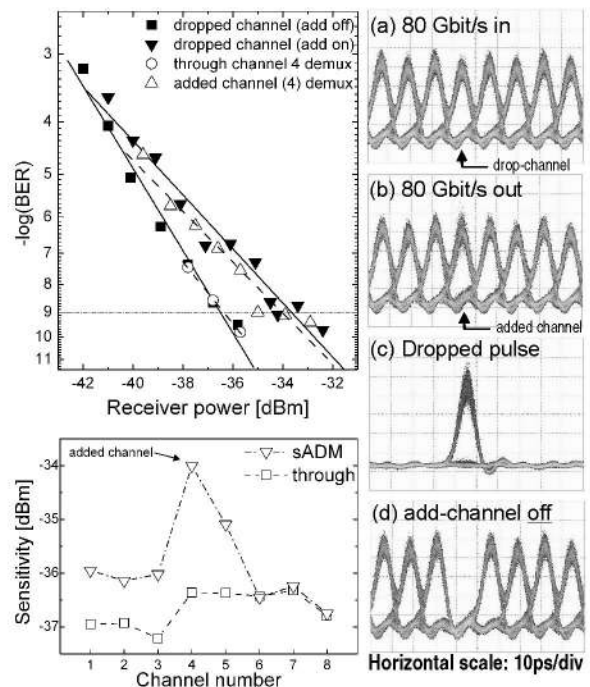

Figure 3: Results. BER measurements (upper left). Sensitivities (lower left). Eye diagrams: (a) 80 Gbit/s sADM input data, (b) 80 Gbit/s sADM output data, (c) dropped pulse, (d) - as (b), but with add-channel off.

Conclusion

We have demonstrated error-free simultaneous add-drop multiplexing in a fibre-based NOLM switch with 400 m HNLF. The add- and drop-operations were performed simultaneously through cross-phase modulation induced by the same control pulse.

References

1 C. Schubert et al, Elec. Lett., 39(2003), 1074
2 H. Chou et al, PTL, 16(2004), 1564
3 C. Schubert et al, OFC 2005, OThN2
4 J.H. Lee et al, PTL, 17(2005), 840
5 E.J.M. Verdurmen et al, ECOC 2005, Th 3.1.7