12P-21

Effect of EDFA saturation cross talk in direct-detection schemes

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Abstract: *The effects of EDFA saturation crosstalk under different modulation schemes were studied. Our experiments show that reconfigurable networks employing DPSK will have less eye closure from saturation crosstalk compared with* NRZ-OOK or QAM.

For multi-channel DWDM systems, both nonlinear phase noise and amplitude noise degrade signal-to-noise ratio (SNR) to different extents. Reconfigurble networks employing reconfigurable optical add-drop multiplexers (ROADM) can have another possible SNR degradation because of the changes in number of channels that affects saturated EDFA performance and produce dynamic gain tilt and gain transient for systems [1]. The effect of saturation-induced gain modulation is found to vanish at higher signal frequencies [2]. Unlike crosstalk from other channels, saturation crosstalk from EDFA cannot be eliminated by band-pass filter.

During channel add/drop in a long haul WDM network, dynamic gain fluctuations lead to transients in survival channels whose characteristics (rise time, power level, etc.) vary with input power, EDFA characteristics and wavelength [3]. Such transients may result in error bursts because of the limited dynamic range of optical receivers. While the compensation of gain transient and gain tilt has been addressed in on-off keying system [4], the effect of which is being studied using other modulation formats in this paper.

When different channels are multiplexed into EDFA and one channel is added/dropped, the add/drop channel introduces power transient in each of the EDFA in the transmission link as shown in Figure 1(a). Transient power fluctuations are also produced in the surviving channels as shown in Figure 1(b). The magnitude of the transient will vary with channel wavelength and input power, and long-term gain-tilt can be introduced after the transient. Depending on the number of EDFA cascaded, surviving channels suffers from BER reduction because of power fluctuation.

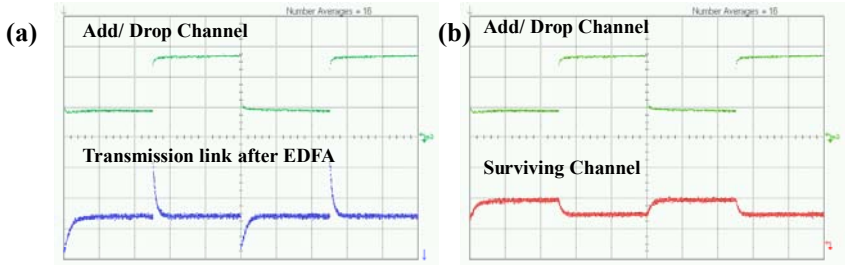

Fig. 1. Effects of channel added/dropped on WDM network after passing through EDFA. (a) Add/drop channel induces transient along transmission link. (b) Transient power fluctuation on one of the surviving channels (red) experienced another channel is added or dropped/ (green).

We compare three direct detection schemes namely on-off keying (OOK), direct detection differential phase shift keying (DD-DPSK) and quadrature-amplitude modulation (QAM) [5]. Figure 2 shows the experimental setup of 16 DWDM channels each with –20dBm output power. A total of –8.23dBm and 11.2dBm averaged power were measured before and after the EDFA, respectively. With near 20dB gain, 15 channels were add/dropped by modulating the output power under 100kHz using pulse pattern generator. The survival channel at 1541.62nm, with different modulation formats, was extracted for SNR analysis. Figure 3 shows the eye diagrams of surviving channel under different modulation schemes with and without saturation crosstalk induced by EDFA.

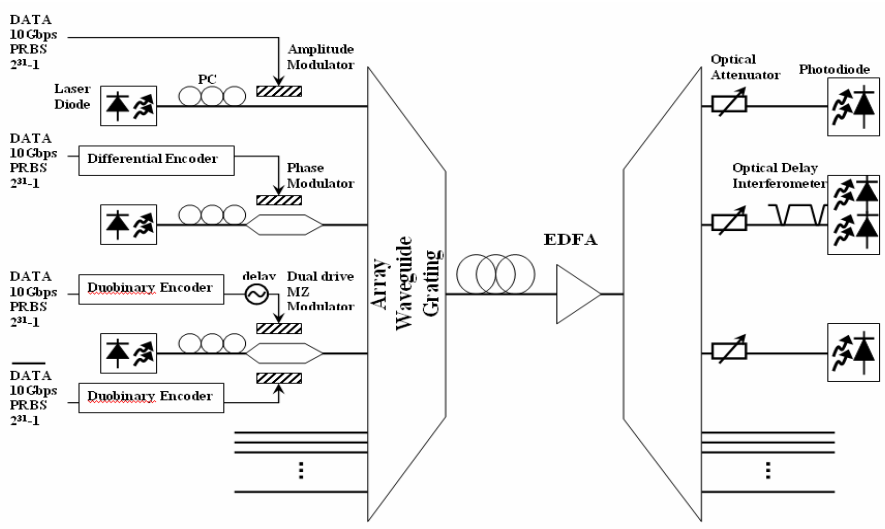

Fig. 2. Schematic representation of different modulation formats.

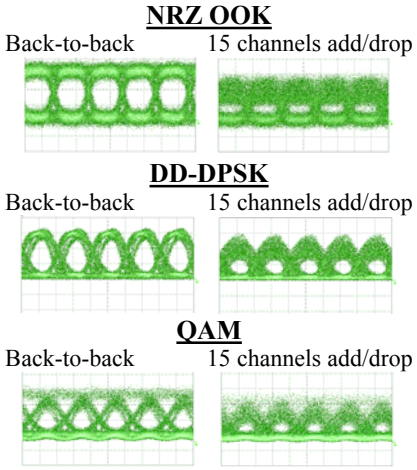

Fig. 3. Demodulated signal eye diagrams of different modulation formats with (right) EDFA saturation crosstalk.

The different eye openings in Fig.3 shows that DD-DPSK has an advantage of less amplitude noise which agrees with corresponding simulation results numerical crosstalk analysis [6]. Other references of optically amplified DWDM systems including FSK [7] will be discussed and simulations as well as experimental results on 10Gb/s transmission will be presented.

Acknowledgements: This work was funded by direct grant project 2050385.

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