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Xu, Zhenbo; Seoane, Jorge; Siahlo, Andrei; Oxenløwe, Leif Katsuo; Clausen, Anders; Jeppesen, Palle

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Experimental characterization of dispersion maps with Raman gain in 160 Gb/s transmission systems

Zhenbo Xu, J. Seoane, A. I. Siahlo, L. K. Oxenløwe, A. T. Clausen P. Jeppesen

Research Center COM, Technical University of Denmark, Kgs. Lyngby, DK-2800, Denmark

Email: xuz@com.dtu.dk

Abstract: We investigate the combined effects of dispersion compensation and Raman amplification in SMF-based transmission span of 160 Gb/s system. The post compensation map shows better power tolerance.

OCIS codes: (060.2330) Fiber optics communications; (060.2320) Fiber optics amplifiers and oscillators

Introduction

Dispersion maps have been investigated for EDFA-based transmission systems [1,2]; and Raman aided 40 Gb/s WDM systems have achieved record transmission distance [3]. In this paper, the combination of dispersion management and Raman amplification is evaluated in a 160 Gb/s single channel system; the optimum dispersion map is proposed.

Schematic of experimental set-up

A schematic of the experimental set-up is shown in Fig. 1. A 10 GHz pulse train is generated by a mode-locked fiber ring laser (ML-FRL) at 1558nm, which is encoded with a 2^7-1 PRBS by a Mach-Zehnder modulator. The modulated signal is launched into a 2^7-1 PRBS maintaining multiplexer (MUX) to generate a 160 Gb/s OTDM data signal. A second pulse train from the ML-FRL is launched into a NOLM (non-linear optical loop mirror) unit that generates the wavelength converted optical clock signal at 1540 nm. The clock and data signals are combined and launched into the fiber span, which is composed of two 40 km SMFs and one 13 km DCF with complete dispersion compensation at 1558 nm. At the output of the span, a 3 dB coupler is used to split the optical power, and two filters are used to select the clock and data signals separately. The optical data and clock signals were injected into the second NOLM for demultiplexing and the clock was also used to drive the BER test set.

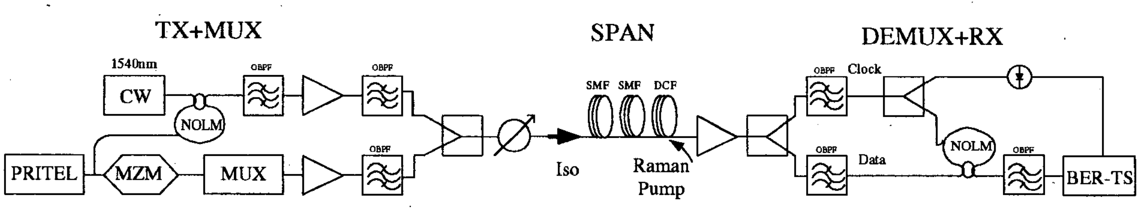

Fig. 1. Experimental set-up, OBPF: optical bandpass filter

Results

First we investigate the span and characterize it with and without Raman amplification by optimizing the signal power in the two cases. The optimal input optical power was 4.5 dBm with and 16 dBm without Raman pump. The system performance in Fig. 2 shows that Raman amplification can improve the receiver sensitivity by 2 dB compared with the EDFA case.

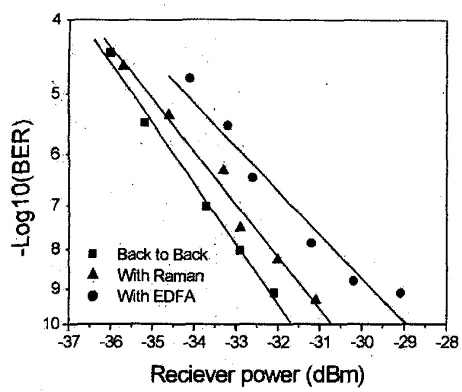

Fig. 2. BER curves for back-to-back, transmission with EDFA and transmission with Raman.

The combined effect of dispersion map and Raman amplification is analyzed in Fig. 3. We apply the same Raman gain at the end of the span to both maps to compensate the fiber loss of 23 dB. The post compensation dispersion map with DCF at the end of the span offers larger tolerance with respect to the launched signal power and less receiver penalty than the symmetrical dispersion map, where the DCF is placed in the middle of the span. The explanation is that for the same Raman gain, post compensation needs less pump power and consequently reduce Raman noise. Our simulation confirms that the non-linear phase shift is smaller when post dispersion compensating.

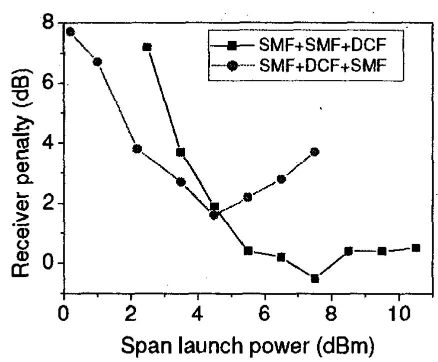

Fig. 3. Receiver penalty of symmetrical and post dispersion compensation with same Raman on-off gain

Conclusion

A transmission span for use in a 160 Gb/s system was investigated with respect to dispersion map and Raman amplification. Raman amplification reduced the transmission penalty by 2 dB compared to the EDFA case. The post compensation dispersion map is more tolerant to launch power.

Reference

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