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The Flexible Dispersion-managed Optical Links with a Randomly Distributed RDPS

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Abstract. Dispersion management (DM), optical phase conjugation (OPC), and the combination of these two are promising techniques to compensate for the signal distortion due to group velocity dispersion and optical Kerr effects of single mode fiber. The goal of this paper is to investigate the system performance depending on the variation degree of the random variable of RDPSs in the optical links for 960 Gbps WDM transmissions.

Keywords: Dispersion-managed Optical Links, Residual Dispersion per Span, Net Residual Dispersion, Optical Phase Conjugation, Pre/Postcompensation, WDM Transmission.

1 Introduction

Dispersion management (DM) using dispersion compensating fiber (DCF) becomes known to a general way to compensate for the signal distortion due to the group velocity dispersion (GVD) of single mode fiber (SMF) [1, 2]. However, DM is efficient only in optical links without nonlinear Kerr effects on optical signals [3].

The effective technique to reduce GVD and nonlinear impairment is through the use of optical phase conjugator (OPC) in the middle of total transmission length. However, the effective suppression of nonlinear impairment is not obtained in WDM transmission systems using only OPC, because nonlinearity cancellation by OPC requires a perfectly symmetrical distribution of power and local dispersion with respect to OPC position [4]. Due to the presence of fiber attenuation, this condition cannot be satisfied in real links. Fortunately, the combining with DM is one of the techniques for overcoming this drawback [5].

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[1] Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames. This determines the structure of the names in the running heads and the author index.

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In most works relating with the only DM techniques and with the combined DM and OPC techniques, DM had been focused on the fixed residual dispersion per span (RDPS) and the length of transmission fiber, such as a SMF for every fiber span. This scheme makes the reconfigurable optical link difficult. As far as the authors know, the analysis and assessment of the optical transmission link to which OPC and DM are applied, with the non-uniform distribution of RDPS in every fiber span, have not been reported yet. Authors had shown the possibility of the flexible optical link configurations using the randomly distributed RDPS in 960 Gbps (40 Gbps × 24 channels) wavelength division multiplexing (WDM) transmission system [6].

In this paper, we investigate the system performance depending on the variation degree of the random variable of RDPSs in the optical links for 960 Gbps WDM transmissions. We assess the optimal net residual dispersion (NRD) and the effective launch power range as the system parameters, through the comparing with the uniform distribution of RDPS.

2 Modeling of Optical Links and Systems for WDM Transmission

The optical transmission link configuration investigated in this research is shown in Fig. 1. The total transmission links consist of 14 fiber spans, which include the SMF and the DCF for DM. We consider 3 cases of the random variables, which are dependent of the variation degree, shown in Table 1, in the optical link with the fixed SMF length of 80 km in all fiber spans. In 3 cases, the averaged RDPSs are assumed to be equal value of 150 ps/nm in both half transmission sections from Tx to the OPC and from the OPC to Rx. In the randomly distributed RDPS optical link, RDPS of each half transmission section is assumed to be selected to be one of six random values summarized in Table 1, except the first and the last fiber spans.

All of the SMFs of the above cases are characterized by the attenuation coefficient α_{SMF} = 0.2 dB/km, dispersion coefficient D_{SMF} = 17 ps/nm/km, and nonlinear coefficient γ_{SMF} = 1.41 $W^{-1}km^{-1}$ at 1,550 nm. Also, all of the DCFs are characterized by dispersion coefficient D_{DCF} = -100 ps/nm/km, attenuation coefficient α_{DCF} = 0.6 dB/km, and nonlinear coefficient γ_{DCF} = 4.83 $W^{-1}km^{-1}$ at 1,550 nm.

Table 1. RDPS and l_{DCF} for the random distribution.

Degree of variation		Random variables					
Gentle	RDPS [ps/nm]	120	130	140	160	170	180
	l_{DCF} [km]	12.4	12.3	12.2	12.0	11.9	11.8
Moderate	RDPS [ps/nm]	0	50	100	150	200	400
	l_{DCF} [km]	13.6	13.1	12.6	12.1	11.6	9.6
Extreme	RDPS [ps/nm]	-1000	-600	-300	600	900	1300
	l_{DCF} [km]	23.6	19.6	16.6	7.6	4.6	0.6

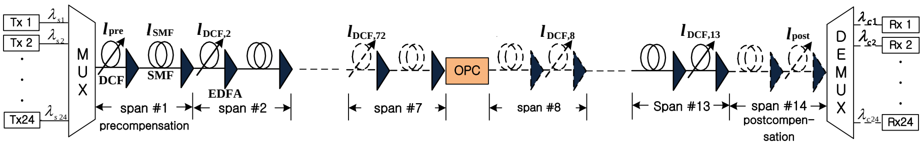


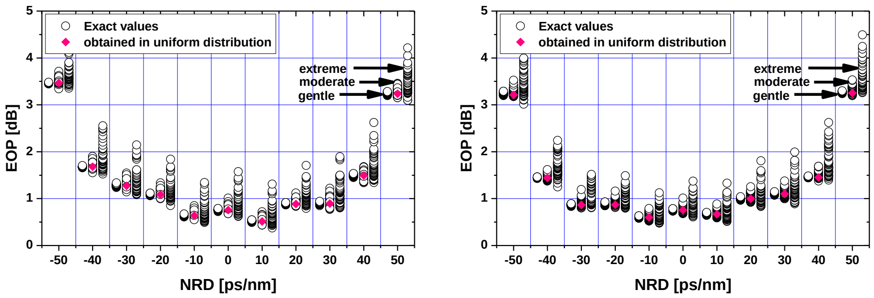
Fig. 1. Configuration of WDM transmission systems and optical links

The NRD is controlled by precompensation or postcompensation as plotted in Fig. 1. In case of determining the NRD by only precompensation, the NRD depends on the variable length of the first DCF, i.e., l_{pre}, the accumulated dispersion in the first SMF, and the total RDPS in the former half section, when the total accumulated dispersion in the latter half section has been fixed to be 0 ps/nm. On the other hand, when the NRD is determined by only postcompensation, it depends on the variable length of the last DCF, i.e., l_{post}, the accumulated dispersion in the last SMF, and the total RDPS in the latter half section when the total accumulated dispersion in the former half section has been fixed to be 0 ps/nm.

We consider the same configurations and parameters of WDM transmitter(Tx), WDM receiver(Rx) and OPC with those of [6].

3 Simulation Results and Discussion

There are many random distribution cases of RDPS. It is difficult to assess the system performance of the overall cases because it is a time consuming process. Therefore, in this work, 50 cases of random distribution are considered for an accurate and simple assessment. Fig. 2 (a) and (b) illustrate the EOPs of the worst channel among the 24 WDM channels with the launch power of -5 dBm as a function of the NRD controlled by pre- and postcompensation, respectively, in the optical transmission links with the randomly distributed RDPS.

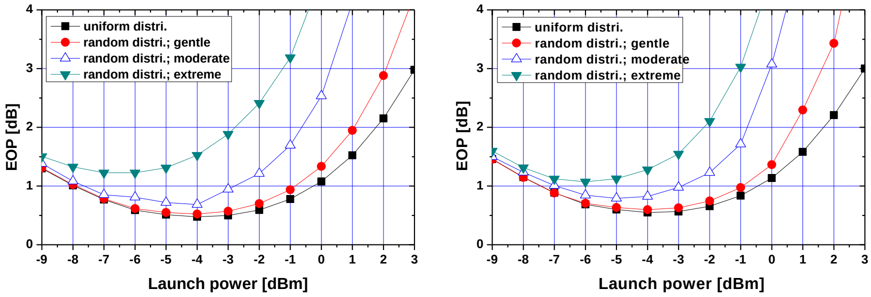


(a) precompensation (b) postcompensation

Fig. 2. The EOPs as a function of the NRD controlled by precompensation and postcompensation in the optical links with the random distribution of RDPS.

It is confirmed that the optimal NRDs were found to be 10 ps/nm or -10 ps/nm in the optical link controlled by precompensation and postcompensation, respectively, which are the same result with our another research of [6]. We also confirm that the optimal NRDs are consistent in the considered launch power (-9~3 dBm). The results of Fig. 2 show the variation of system performance is more increased as the variation degree of RDPS random variable is more increased.

Fig. 3 (a) and (b) illustrate the worst EOP as a function of the launch power of the worst channel in the optical links with the optimal NRD of 10 ps/nm and -10 ps/nm by precompensation and postcompensation, respectively. We define the launch power results in the EOP below 1 dB as the effective launch power. It is confirm that the range of the effective launch power strongly depends on the variation degree of the random variable of RDPS.



(a) precompensation (b) postcompensation

Fig. 3. The EOPs as a function of the launch power in the optical links with the optimal NRD.

4 Conclusion

The system performance depending on the variation degree of the random variable of RDPSs in the optical links for 960 Gbps WDM transmissions was investigated in this paper. We confirmed that the difference of RDPS between the fiber spans has to be small for the excellent compensation in the optical links with the randomly distributed RDPS.

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