

Non Linearities & Dispersion Management in Advanced Communication

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Abstract: Optical communication is identified as one of the advanced communications systems. Dispersion & non-linear effects cause severe waveform distortion in single channel as well as Wavelength Division Multiplexing (WDM) systems. Of Two methods like Dispersion Compensation Fiber and Optical phase compensation, Results are reported for dispersion Compensation fiber.

Keywords: Dispersion, WDM, compensation, non linear effects, single channel

1. Introduction

Among the various communication media such as coaxial cables, twisted pairs, optical fibers, radio frequency, satellites, optical fiber is the only medium with enormous bandwidth to handle the rapidly growing high capacity backbone into the world today. The optical fiber is often seen as a perfect transmission medium with almost limitless bandwidth. However in practice, the propagation through optical fiber is the best with several limitations especially as distance is increased to multi span amplified systems [1]. As the transmission systems evolved to longer distances and higher bit rates, the linear effects of fibers i.e. attenuation and dispersion become the important limiting factors. As per WDM systems that transmit multiple wavelengths simultaneously at even higher bit rates and distances, the non linear effects in the fiber begin to present a serious limitation.

The success of high bit rate long haul point to point optical transmission networks depends upon how best the linear and non linear effects are managed. The major linear effects include group velocity dispersion (GVD) of standard single mode fiber, fiber loss, adjacent channel X-talk, polarization mode dispersion (PMD), accumulated ASE noise etc. The non linear affects on the other hand include self phase modulation (SPM), cross phase modulation (XPM), stimulated Brillouin scattering (SBS), stimulated Raman scattering (SRS) and four wave mixing (FWM). [2]

2. Description of the Methods Used in For Non Linear & Dispersion Compensation

The first step towards dispersion management was to develop some suitable fiber having low dispersion. Then the next issue is the dispersion slope management in high bit rate single channel systems. The dispersion arrangement, which considers both the second and third order dispersion characteristics, is shown in the Fig.1. For second order dispersion control, we arrange the PDF (dispersion value D_{2p} , length is L_p) and NDF (D_{2n} and L_n) so that the subtotal of their product in each repeater span i.e., is not zero but remains a constant value. This is because the local second order dispersion value should be as large as possible to reduce the inter channel interaction caused by non linearity. The system composed of M spans of sets of PDF

and NDF and the length of PDF for dispersion compensation is given by L_p then the second order dispersion value of a unit dispersion management span is expressed as [3]

$$\hat{D}_{2S} = \frac{D_{2p}(ML_p + L'_p)L_p + MD_{2n}L_n}{L_s} \quad (1)$$

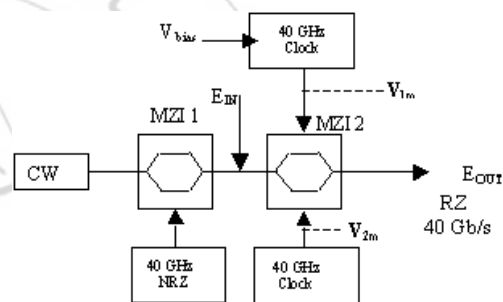


Figure 1: Generation of 40Gb/s CSRZ

The second order dispersion value before compensation by PDF is given by

$$\hat{D}_{2S} = \frac{D_{2p}L_p + D_{2n}L_n}{L_p + L_n} \quad (3)$$

which would typically be minus a few ps/ nm/ km for effective suppression of inter channel interference. Fig.2, shows the schematic of SMF and DCF. Its dispersion map is exemplified as below.

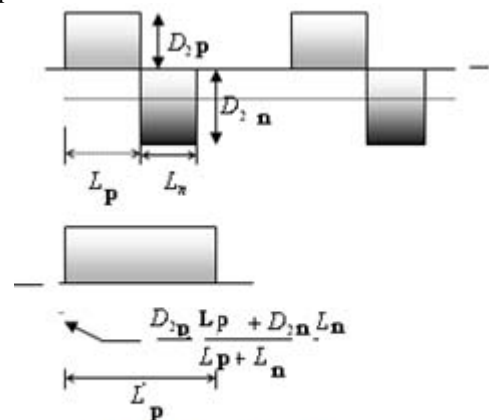


Figure 3 Dispersion map for the DCF compensation scheme

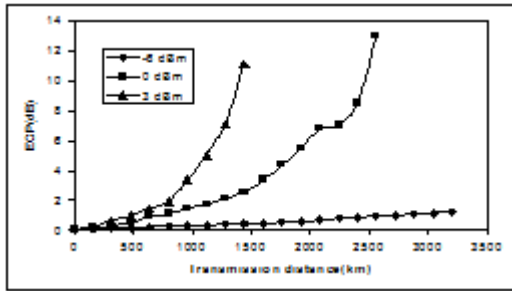


Figure 4: Eye opening penalty vs Transmission distance for NRZ signal for different average input power

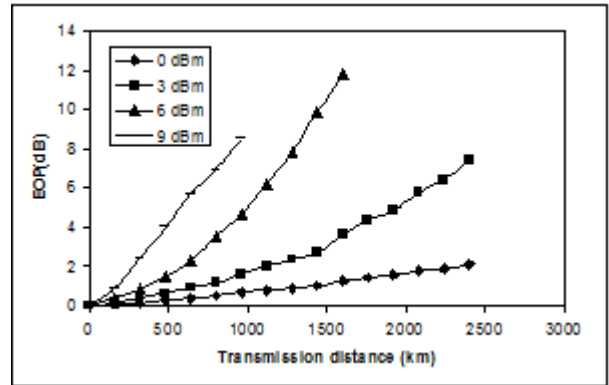


Figure 5: Eye opening penalty vs Transmission distance for RZ signal for different average input power

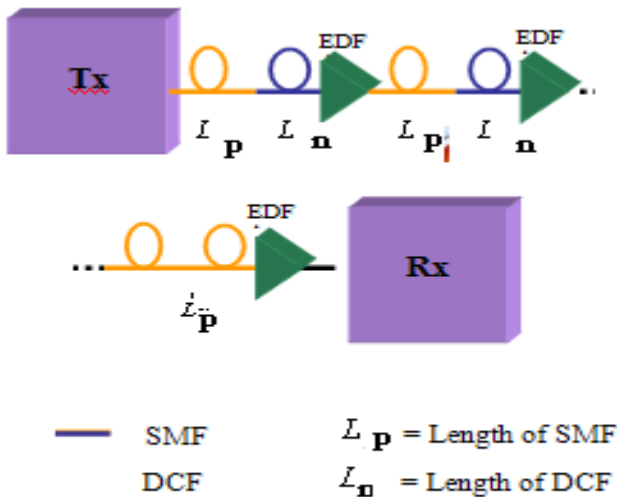


Figure 2: Schematic of SM and DCF

The third order dispersion value of the span L_s is given by

$$D_{3s} = \frac{D_{3p}(ML_p + L'_p) + MD_{3n}L_n}{L_s}$$

To suppress significant waveform distortion, the lengths of PDF and NDG fibers should be chosen to satisfy the following relations

$$L_{D2p} = \frac{T_0^2}{\beta_{2p}}, L_{NLp} = \frac{1}{\gamma_{pP}}$$

$$L_{D2n} = \frac{T_0^2}{\beta_{2n}}$$

and $L_{NLn} = \frac{1}{\gamma_n P_n}$,

Are the dispersion and nonlinear lengths of PDF and NDF respectively.

3. Results and Discussion

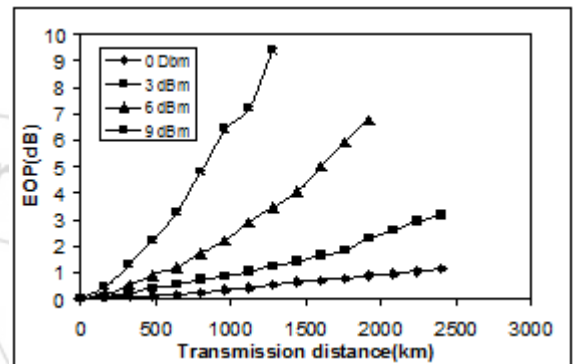


Figure 6: Eye opening penalty vs Transmission distance for carrier suppressed RZ signal for different average input power

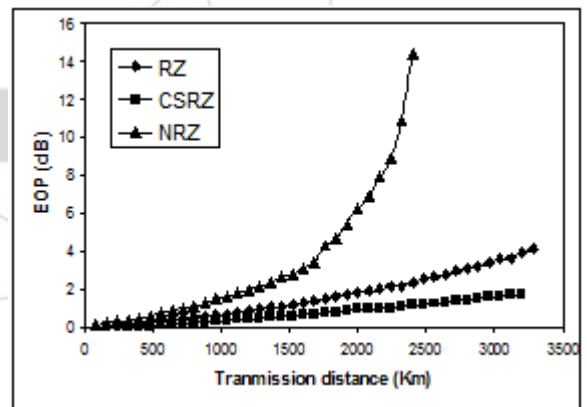


Figure 7: Comparison of different modulation formats for single channel DCF compensation for average input power of 0dBm

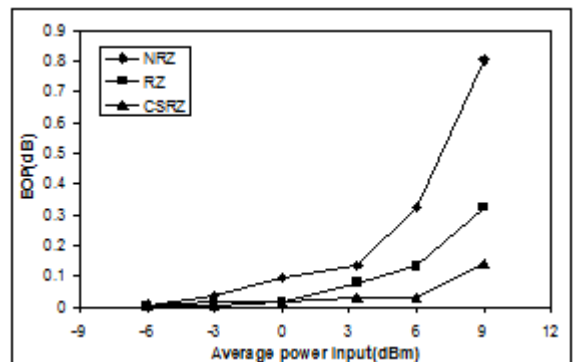


Figure 8: Comparison of different modulation formats for single channel DCF compensation for different input powers at a transmission distance of 320km

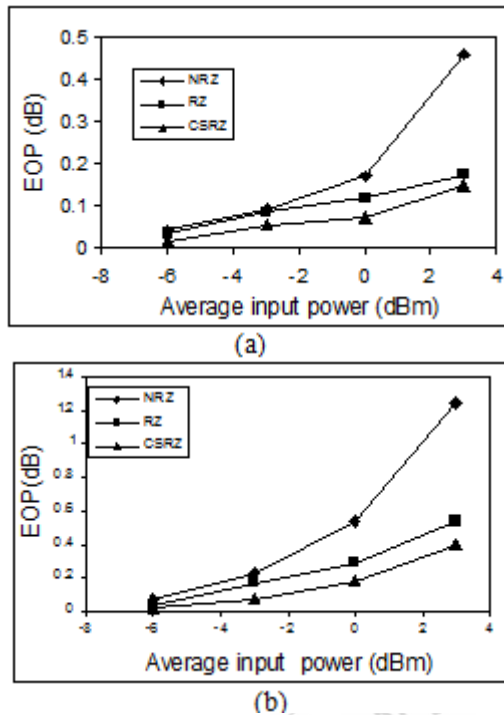


Figure 9: Comparison of different modulation formats with respect to EOP in a 4x40Gbps transmission system employing DCF compensation with channel spacing of 100GHz for a transmission distance of 320km(a), and 800 km (b)

The results generated using MATLAB are reported from Fig.4 to Fig.9. Eye opening penalty of NRZ is comparatively moderate for 0dB average output power. For RZ signal as shown in Fig.5, the slope found to be progressively decreased. Fig.6 shows the decrement of slope of the EOP with signal power. However, 9dBm power shows the sustainability for longer distances. Fig.7 highlights the CSRZ technique that has very small slope compared with others. The same is confirmed in Fig.8 for a limited distance of 320Km transmission distance. Fig.9, compares the same for 800 Km also. This shows the nearness of CSRZ and RZ format.

4. Conclusions

The compensation of dispersion and dispersion slope using DCF is studied. This type of compensation technique works well for lower input powers. As this compensation technique does not compensate non linearity, it shows layer eye opening penalty at higher input powers. Also as the nonlinear coefficients of the dispersion coefficient fiber is high, the nonlinearity is more. For this the power launched into the DCF is properly chosen. Here in our simulations we have compensated the total loss over the PDF by using EDFA and it is launched into the DCF. This compensation is economically suited for short range application.

References

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