International Journal of Engineering Research and General Science Volume 3, Issue 4, July-August, 2015
ISSN 2091-2730

Comparison of different compensation techniques for 96 channel DWDM system

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Abstract- In this paper, we investigate pre-, post-, symmetrical dispersion and power compensation in parallel for 96 channels ×10 Gbps non-return to zero DWDM system using pumped dispersion compensating fiber (PDCF) and pumped single mode fiber (PSMF). The results of three compensation methods have been compared in the term of bit error rate, eye closure penalty and Quality factor and it has been found that both post- and symmetrical compensation methods provide better results for short haul communication but for long haul communication post-compensation method is the best alternative among other. The impact of bit error rate and eye closure penalty is also observed for large transmission distances.

Keywords: DWDM, Pumped dispersion compensating fiber, Pumped single mode fiber, Channel spacing, BER, Q-value, Compensation technique.

Introduction

The development of powerful optical amplifiers, which eliminate the expensive conversion of optical - to – electrical and vice versa provide better result for long haul transmission. To compensate the power losses various optical amplifiers EDFA, SOA, Raman amplifier and HOA are used. HOA is an open area of research because it enhanced the bandwidth and maximizes the span length. In high capacity WDM system, with increase in the channel bit rate from 10 to 40 Gbps there is non-linear impairments changes [8]. The signal will have a number of fiber non-linear effects, such as chromatic dispersion as transmission distance and number of channel increases. Several methods have been proposed to overcome the impairments caused by chromatic dispersion including fiber bragg grating, optical phase conjugation, dispersion compensating devices. Power & DCF is an important method to upgrade the already installed links of SMF. The high value of negative dispersion is used to compensate positive dispersion over large lengths of fiber. Nuyts et al. [6] investigated that as the launching power into DCF is increased, the DCF length which offers widest eye margin decreases and this results in an increased SNR, therefore performance of the system is improved. Rothnie et al. [7] demonstrated that the transmission performance is improved in each amplified section by placing the DCF before SMF. Kaler et al. [5] investigated the three dispersion compensation methods for 10 Gbps NRZ links and EDFA is used as power compensator. The results show that symmetrical compensation is superior to that of Pre- & Post- compensation and maximum transmission distance for Post-compensation is up to 288 km. Randhawa et al. [3] compared the three compensation techniques in presence of fiber nonlinearities in 10 Gbps & 40 Gbps CSRZ system & observed that Hybrid compensation provide better result for high speed optical system. Tiwari et al. [9] achieved dispersion & power compensation in parallel by using pumped DCF means Raman amplification has been done by using counter pumped DCF (PDCF). In this paper the work is extended with context of 10 Gbps x 96 channels DWDM system. To amplify this broadband system i.e. 120.4 nm of gain band width, HOA (Raman-EDFA) is considered and achieved power & dispersion compensation in parallel. Transmiiter consists of data source, electrical driver, laser source and amplitude modulator. The data source is non – return to zero (NRZ) format at bit rate of 10 Gbps. CW laser generate 96 laser beams with 100 Ghz of interval over 120.4nm bandwidth. The combiner C, combine all the modulated optical signals, boosted by EDFA booster then fed to optical fiber through an optical splitter, S. Optical splitter is used to measurement of optical power and to analyze the optical spectrum for transmission link. After that for the Pre-, Post- and Symmetrical compensation the PDCF-EDFA & PSMF-EDFA is used. At the receiver side the optical signal detected by PIN detector, then passed through the electrical filter (Besssel) and output observed on electroscope. Eye diagram, Q-factor and BER measured from electroscope.

RESULT & DISCUSSION

The parameters of PSMF and PDCF considered are given below:

Table 1

Parameters	PSMF	PDCF
Length	Shown in table 2	Shown in table 2
Fiber – non linearity	Considered	Considered
Raman crosstalk	Not considered	Not considered
Fiber polarized mode dispersion	Considered	Considered
Fiber birefringence	Considered	Considered
Operating temperature	300	300
Pump type	Counter – propagate	Counter – propagate
Pump wavelength (nm)	1453	1453
Pump power (mW)	1000	200
Pump attenuation (dB/km)	1.2	1.2
Dispersion (ps/nm/km)	16	-96

The total length of communication link is changed according to ten cases which are considered for varying the length of DCF and SMF.

Table 2

Case	DCF(km)	SMF(km)
1	4	24
2	6	36
3	8	48
4	10	60
5	12	72
6	14	84
7	16	96
8	18	108
9	20	120
10	22	132

For the first case the length of DCF is 4 km and SMF is 24 km and for second case the length of DCF is 6 km and SMF is 36 km. This process is taken up to 10 cases for which the length of DCF is 22 km and SMF is 132 km. It has been found that case 4 shows the best result. It means when the length of DCF is 10km and SMF is of 60 km the results are good. For this case, the Q-factor is 23.84db, 23.84db, 23.35db for the Pre-, Post- and Symmetrical compensations respectively and BER is 10^{-40} for all compensation techniques. And eye closure is 0.61db, 0.58db and 0.68db for the Pre-, Post- and Symmetrical compensations. Therefore length of the fiber is considered according to case 4. The bit error rate for the different compensation methods is measured for various cases. And it is observed that performance is better for Post-compensation method than Pre- and Symmetrical configuration. Both Post- and Symmetrical compensation provides acceptable bit error rate i.e., 2.3 x 10^{-10} for Post- and 1.9 x 10^{-9} for Symmetrical compensation up to 420 km and degraded after this distance. Further the eye closure penalty indicates that the Post-compensation method provide least eye closure (<1.73 db for all transmission distances) as compared to other methods. The 6 spans of Post- compensation and 3 spans of Symmetrical compensation cover 420 km distance but the Pre- compensation is used to cover up to 350 km distance only after that there is degradation of the signal.

Conclusion

The paper illustrate the performance comparison of pre-, post-, symmetrical dispersion and power compensation in parallel for 96 channels × 10 Gbps non-return to zero DWDM system using pumped dispersion compensating fiber (PDCF) and pumped single mode fiber (PSMF). It is found that both post- and symmetrical compensation methods are provide better results for short haul communication compare to pre - compensation but for long haul communication post-compensation method is the best alternative among other. Also, the influence of transmission distance on the three compensation methods has been discussed by keeping the fiber length constant (10 km of PDCF and 60 km of PSMF). For acceptable bit error rate ≤ 10^{-9}, maximum transmission distance for post and symmetrical compensation is up to 420 km, i.e. 6 and 3 spans of post- and symmetrical compensation configuration for case (4), where as it is approximately up to 350 km for the pre-compensation method.

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