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10 Gbit/s OPTICAL SOLITON TRANSMISSION EXPERIMENT IN A COMB-LIKE DISPERSION PROFILED FIBER LOOP

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Abstract: We performed 10 Gbit/s optical soliton transmission experiment over 2,000 km with bit error rate of < 10^{-9} in a comb-like dispersion profiled fiber loop of 80 km amplifier spacing which corresponds to nearly the twice of dispersion distance.

Introduction

Optical soliton transmission[1] is one of the most attractive techniques for future optical communication systems because of their potential of long-haul and/or high bit-rate communication. In a lumped transmission system using typical EDFA's, however, the amplifier spacing z_a is required to be much shorter than the dispersion distance z_0 in order to achieve stable soliton transmission[2, 3]. This is a severe restriction when one wants to increase the bit rate of the system because z_0 is inversely proportional to the square of soliton pulse width. Although the use of synchronous intensity modulation[4] at each EDFA is effective not only to expand z_a[5] but also to reduce the Gordon-Haus timing jitter[6], it may result in system complexity. Another method to expand z_a is to vary the dispersion of transmission fiber in accordance with the peak power of transmitting solitons[7, 8]. This method has the advantage in the sense that no active device are required. However, it is difficult to manufacture dispersion decreasing fiber of nearly 100 km with accurate dispersion profile at the moment. In this paper, we construct a recirculation loop using comb-like dispersion profiled fiber[9] (CDPF) using standard single mode fiber and dispersion shifted fiber with the total length of 80 km to demonstrate a 10 Gbit/s optical soliton transmission.

Experiment

Figure 1 shows the experimental setup. 10 Gbit/s optical pulses of 1553 nm are generated by a DFB laser diode, an MQW electro-absorption modulator which is driven by a - 2.5 V dc and a 10 GHz RF signal of + 16 dBm, and a $LiNbO_3$ intensity modulator. The pulse width after the DCF with the group delay dispersion of - 50 ps/nm used for chirp compensation was 13 ps. The CDPF was constructed by 8 sections of a standard single-mode fiber and a dispersion shifted fiber[10] as shown in the Figure 2. The average dispersion, the propagation loss including fusion splicing losses of the CDPF were 1.0 ps/nm/km and 19 dB, respectively. The average dispersion distance is calculated to be 43.5 km when the pulse width is 13 ps. An acousto-optic modulator (AOM2) was used for switching recirculating light. The transmitting light thus makes frequency shift of + 110 MHz. Nevertheless, the normalized frequency shift is only 2.7 x 10^{-3} due to the long loop length when the soliton pulse width is 13 ps, so that the effect of sliding frequency soliton control[11] is negligibly small. The use of AOM to inject and/or pick up the signals instead of an optical directional coupler[12] reduces the loss of the recirculating loop. This improves the transmission characteristics especially when only a few EDFA's are used in the loop and the pump power of EDFA's are limited. In the CDPF, we inserted an 1-nm-bandwidth optical bandpass filter (OBPF) which slightly improved the transmission characteristics. The transmitted pulses were observed by fast O/E converter and sampling oscilloscope.

Figure 1: Setup for 10 Gbit/s optical soliton transmission experiment using comb-like dispersion profiled fiber (CDPF) loop.

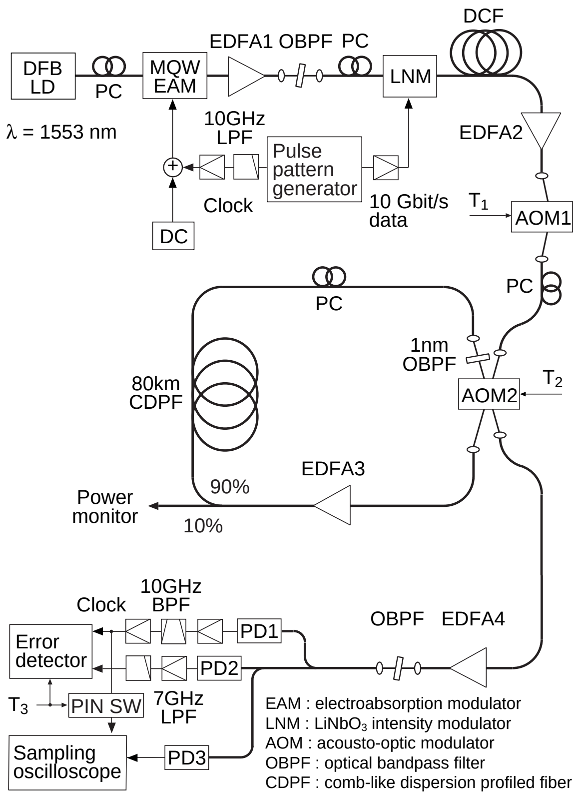

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Figure 2: Dispersion map of the CDPF. Inset shows dispersion map of each section.

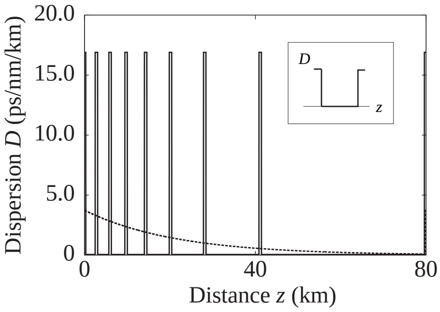
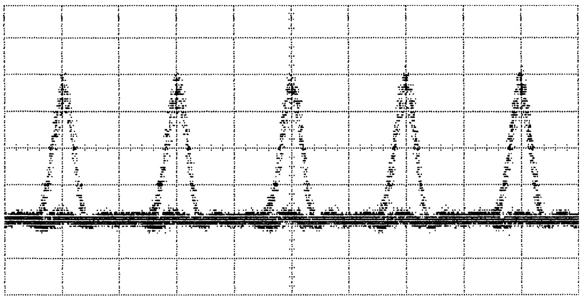
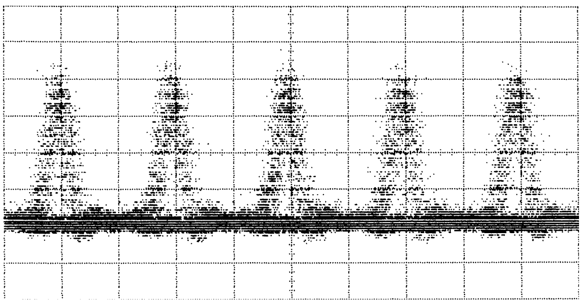


Figure 3 shows the observed eye patterns of the transmitted pulses at (a) 0 km and (b) 2,000 km. The average power of 10 Gbit/s optical solitons at the input end of the CDPF was + 12.6 dBm. Although noise accumulation can be seen after 2,000 km transmission, pulse width is almost the same as the input one. Figure 4 shows the measured bit error rate (BER) versus transmission distance. BER of < 10^{-9} was obtained over 2,000 km transmission.

Figure 3: Observed eye patterns of transmitted solitons.

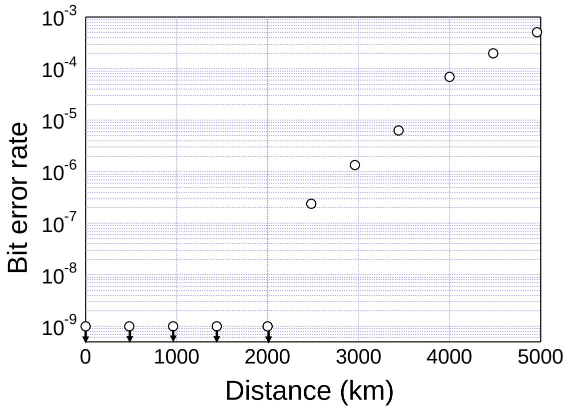


(a) 0 km



(b) 2,000 km

Figure 4: Measured BER versus transmission distance.



Conclusion

In conclusion, 10 Gbit/s optical soliton transmission experiment has been performed in a comb-like dispersion profiled fiber loop of 80 km which corresponds to 1.8 times of the dispersion distance. Future work includes reduction of number of sections of the CDPF.

references

/1/ A. Hasegawa and Y. Kodama, "*Solitons in optical communications*," Oxford University Press, New York (1995).

/2/ A. Hasegawa and Y. Kodama, *Opt. Lett.*, **15**, 1443 (1990).

/3/ K. J. Blow and N. J. Doran, *Photon. Tech. Lett.*, **3**, 369 (1991).

/4/ M. Nakazawa, E. Yamada, H. Kubota, and K. Suzuki, *Electron. Lett.*, **27**, 1270 (1991).

/5/ G. Aubin, T. Montalant, J. Moulu, B. Nortier, F. Pirio and J.-B. Thomine, *Electron. Lett.*, **31**, 217 (1995).

/6/ J. P. Gordon and H. A. Haus, Opt. Lett., **11**, 665 (1986).

/7/ W. Forysiak, F. M. Knox, and N. J. Doran, *IEEE/OSA J. Lightwave Technol.*, **12**, 1330 (1994).

/8/ D. J. Richardson, L. Dong, R. P. Chamberlin, A. D. Ellis, T. Widdowson and W. A. Pender, *Electron. Lett.*, **32**, 373 (1996).

/9/ S. V. Chernikov, J. R. Taylor and R. Kashyap, *Electron. Lett.*, **29**, 1788 (1993).

/10/ H. Toda, Y. Furukawa, T. Kinoshita, Y. Kodama and A. Hasegawa, *Photon. Tech. Lett.*, **9**, 1415 (1997).

/11/ Y. Kodama, M. Romagnoli and S. Wabnitz, *Electron. Lett.*, **30**, 261 (1994).

/12/ H. Toda, H. Yamagishi and A. Hasegawa, *Opt. Lett.*, **20**, 1002 (1995).