LOCATION EFFECT OF DISPERSION COMPENSATION ELEMENTS IN 40 Gbit/s SOLITON TRANSMISSION LINE

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Abstract: Location effect of dispersion compensation elements in 40 Gbit/s soliton system is studied. The wavelength tolerance for error free transmission is 1.2-nm with chirp-free DCF allocation, 3-times improvement has achieved without pre-chirping technique.

Introduction

40 Gbit/s based RZ system is expected as the next generation medium distance ultra-high capacity communication systems /1/. In this region, fiber dispersion effects and nonlinear effects become critical, so the dispersion managed (DM) soliton is an attractive solution. It was reported that the initial frequency chirping enhances the power margin and dispersion tolerance /2/, but the optimization of dispersion compensation elements has the same effect on transmission characteristics. We evaluate the location effect of compensation elements by the 640 km single-channel transmission experiment using conventional DSF.

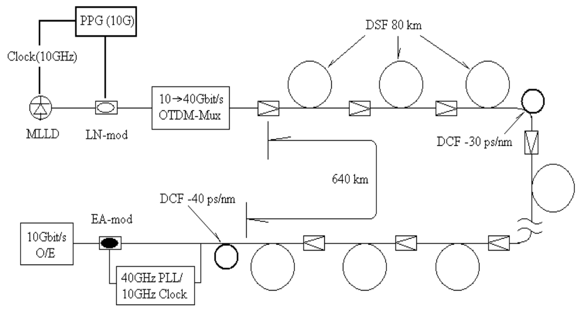


Figure 1 : Experimental setup of the 40 Gbit/s, 640 km transmission system.

Experimental setup

The experimental setup is shown in the Figure 1. The optical pulse is generated by a mode-locked laser diode (MLLD), and the pulse width is 5.7 ps. This MLLD can be tuned between 1530 nm and 1560 nm wavelength range. The MLLD is triggered by 10 GHz clock signal. The output pulse is modulated by the lithium niobate modulator (LN-mod), and the output 10 Gbit/s, 2^{15}-1 PRBS data pattern is optically multiplexed to 40 Gbit/s signal by a PLC-multiplexer.

The dispersion-shifted fibers (DSF) are used for the transmission line. The amplifier spacing is 80 km, and each span is consisting from 4-pieces of 20 km length DSF. The zero-dispersion wavelength of the each fiber is distributed between 1535 nm and 1560 nm, their standard deviation is 6.1nm. The 2-pieces of dispersion compensation fibers (DCF) of –30 ps/nm and –40 ps/nm are installed in the transmission line. The averaged zero-dispersion wavelength is 1547.9 nm (without DCF), and 1549.5 nm (with DCF).

The amplifier noise Figure is 5 dB, and no-filter is used in each amplifier. The fiber loss rate is 0.21 dB/km, and the dispersion slope is 0.07 ps/nm^2/km. The average dispersion of the transmission line can be changed according to the laser-wavelength.

In the receiver, 10 GHz clock signal is recovered by the 40 GHz phase locked loop circuit (PLL), and the 40 Gbit/s data stream is demultiplexed to 10 Gbit/s signal using an electroabsorbtion modulator (EA-mod).

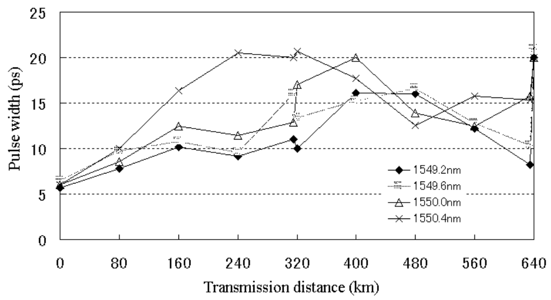
Location effect of the dispersion compensation elements

In the dispersion compensated soliton systems, the pulse width becomes minimal around the center point of the dispersion compensation spans, where the frequency chirp becomes zero. Therefore, if we put the pulse source and the receiver at the chirp-free points, any pre-chirping or chirp compensation at the receiver is not required to get the optimal DM-soliton transmission.

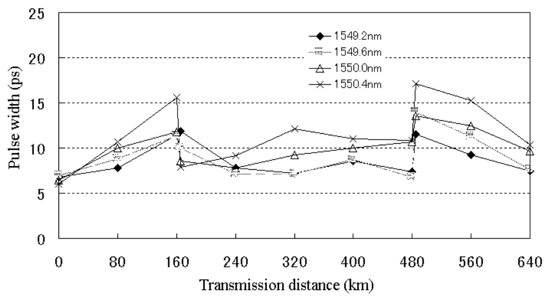
Figure 2 shows the observed pulse widths in two types of dispersion compensation lines by a streak camera. The signal power is +7 dBm, which is the optimal power for the transmission. In the case (a) the DCFs are installed in the end point of the compensation spans, 320 km and 640 km (ordinary DCF allocation). In the case (b) these are installed in the center point of the spans, 160 km and 480 km (chirp-free DCF allocation).

The average pulse widths at the receiver for 1549.2 nm to 1550.4 nm signals are 20.2 ps in the case (a), and 8.8 ps in the case (b). The pulse broadening is suppressed and intersymbol interference (ISI) is reduced in the case (b).

Figure 3 shows the measured bit error rate for these two types of lines. In the case (b), the error-free transmission is observed in the wavelength range of 1.2 nm: 1549.4 nm - 1550.6 nm, expanded 3 times compared to the case (a).



(a) DCF: 320km, 640km



(b) DCF: 160km, 480km

Figure 2 : Measured pulse width for the two types of dispersion compensation line.

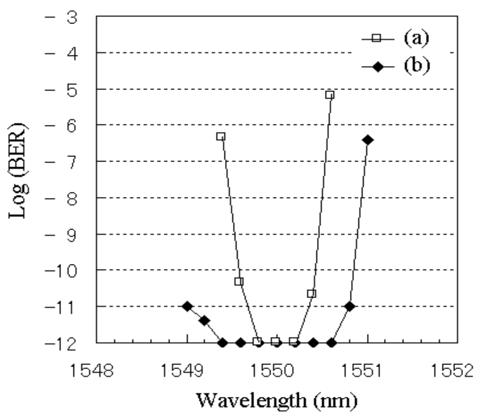


Figure 3 : Performance improvement by the location effect of DCF.

We confirmed the location effect of the dispersion compensation element by the numerical simulation with Q-map method /3/.

Figure 4 shows the dispersion map of the simulation model. The accumulated dispersion is periodically compensated by the compensation element *Dc*. There are two extremely stable transmission conditions in this type of line, these conditions have opposite dispersion compensation *Dc* and initial frequency chirp *C* /4/.

Figure 5 shows these two stable conditions for ordinary DCF allocation and chirp-free allocation. The average dispersion is fixed to +0.03 ps/nm/km. In the ordinary DCF allocation case (a), *C* > 0 (down-chirping) is required for the positive *Dc* lines, and *C* < 0 (up-chirping) is required for the negative *Dc* lines. In the chirp-free DCF allocation case (b), pre-chirping is not required for the optimal transmission, and transmission performance is improved especially in the positive *Dc* lines.

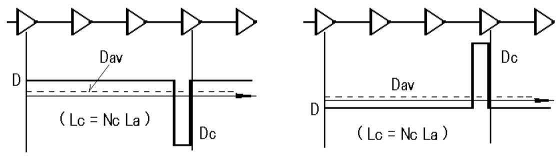
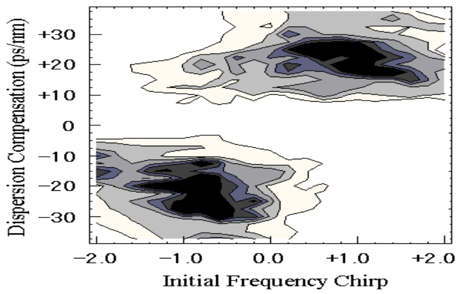
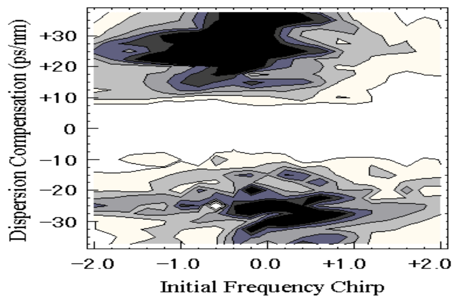


Figure 4 : Dispersion map of negative Dc line (left), and positive Dc line (right).



(a) Ordinary DCF allocation



(b) Chirp-free DCF allocation

Figure 5 : Q-map for the initial frequency chirp and dispersion compensation.

Conclusion

We observed remarkable improvement of the transmission performance by the location effect of the dispersion compensation elements. In the 40 Gbit/s, 640 km transmission using 2-pieces of dispersion compensation fibers, the error-free transmission is achieved in the wavelength range of 1.2 nm in the chirp-free DCF allocation. Numerical simulation confirms these results.

References

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