SINGLE CHANNEL 80Gbit/s OTDM TRANSMISSION THROUGH A 800km DISPERSION SHIFTED FIBER

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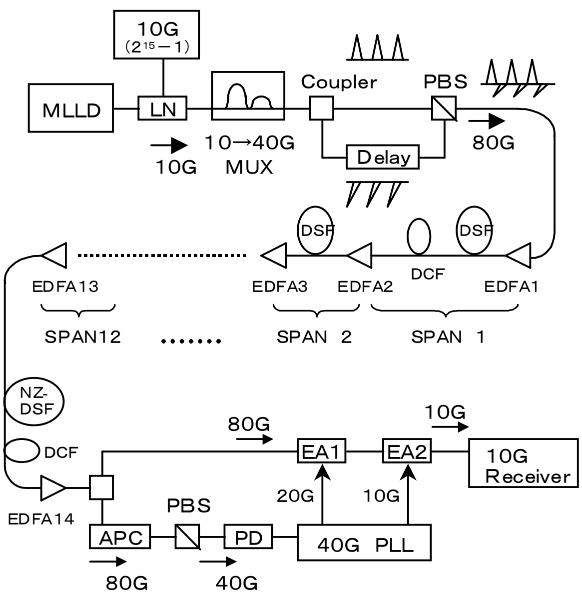
Abstract: Single channel 80Gbit/s OTDM transmission over 800km is demonstrated. Transmission line is mainly composed of DSF with various zero dispersion. Using techniques of dispersion management and polarization interleave multiplexing, error free transmission is achieved.

Introduction

Ultra-high-speed optical time-domain-multiplexed (OTDM) transmission is a key technique for optical communication systems in the next generation. Recently, experiments on single channel OTDM transmission at over 80Gbit/s in bit rate and 10,000km in transmission distance have been carried out /1/. In those experiments, a recirculating method was employed. On the other hand, the transmission distance for straight lines is limited to the order of 500km /2//3/. In transmission experiments using a long straight line, large variation in chromatic dispersion of the fibers was found to be unavoidable. Strong restrictions are therefore imposed on setting signal wavelength and optical powers. These difficulties might be mitigated by a dispersion management technique.

In this paper, we show the usefulness of dispersion management through an experiment where dispersion shifted fibers (DSF) with various zero dispersion wavelengths (ZDW) are used. The transmission line is composed of 720km DSF, 80km NZ-DSF, and dispersion compensation fibers (DCF). The NZ-DSF is used only for experimental convenience. Error-free transmission at 80Gbit/s is successfully demonstrated over an 800km straight line.

Fig.1 Experimental Setup of 80Gbit/s OTDM Transmission.



Experimental setup

The experimental setup is shown in Fig.1. The 80Gbit/s polarization multiplexed OTDM signal is generated as follows. A mode locked semiconductor laser (MLLD) is used to generate 10GHz repetition rate, 4ps FWHM pulses. Then the pulses are modulated by a 10Gbit/s (PRBS 2^{15}-1) signal using a $LiNbO_3$ (LN) modulator. A planar lightwave circuit is used to multiplex optically the 10Gbit/s signal into a 40Gbit/s data train. The 40Gbit/s linearly polarised signal is divided into two channels by a 3dB optical coupler and adjustable time delay unit is inserted in one channel. Then, they are multiplexed by a polarization beam splitter (PBS) with orthogonal polarization condition. By adjusting the optical delay unit, two signals are interleaved.

The 800km transmission line consists of 12 DSF spans and one NZ-DSF span. The span length of the DSF is 60km. Optical filters with a 3nm bandwidth are included in the EDFA 5, 10 and 14 to suppress ASE originating from the EDFA's. DCF's are inserted after the DSF at every odd span. The location of the DCF is important. In the experiment of 40Gbit/s signal transmission over 640km, compensation at two points in the line was sufficient /4/. At present, the number of compensation points is increased considering the high bit rate. The fibers in each span are roughly arranged in dispersion-decreasing manner to reduce the influence of the dispersive waves. The average dispersion of each span is set to be roughly the same in order to make the dispersion management easy.

At the receiver, clock is recovered as follows. Branched 80Gbit/s pulse train is incident on the PBS after adjustment of the polarization state by an automatic polarization controller (APC). Thus, the 80Gbit/s signal is demultiplexed into the 40Gbit/s signal according to the polarization discrimination. Locking a 40GHz phase locked loop (PLL) to an output of the pin-PD, the clock is obtained.

Fig.2 Dispersion map of the transmission line.

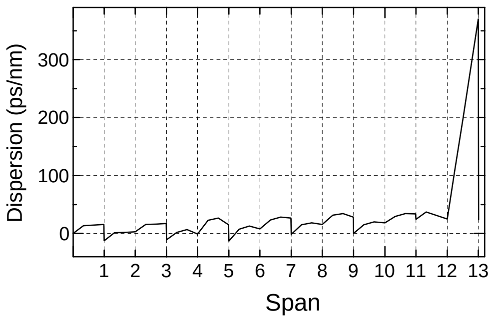
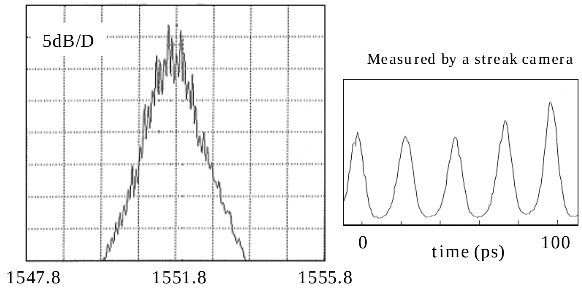


Fig.4 Spectrum and waveform of the received signal.



Another 80Gbit/s optical signal is demultiplexed to 10Gbit/s signals using two EA modulators. The EA modulators are driven at frequencies of 20GHz and 10GHz, respectively, synchronized with the 40GHz PLL. Bit error rates (BER) are measured for these 10Gbit/s signals. The 40Gbit/s signal appearing in one branch of the PBS might be demultiplexed into 10Gbit/s signals using a single EA modulator. However, the BER was unstable due to the insufficient operation of the APC.

Transmission Experiments

Wavelength is set at 1551.7nm which is determined from the request for the dispersion management because the dispersion of the unit DCF is 30ps at 1550nm in the present case. Unless using the dispersion management scheme, the signal wavelength is uniquely fixed. In our case, the long distance transmission was difficult because the wavelength was close to the ZDW of many fibers. Fig.2 shows the dispersion map of the transmission line at 1551.7nm. It is theoretically predicted that the transmission fiber should have anomalous dispersion in average. The present wavelength of 1551.7nm is 0.5nm apart from the average zero dispersion of the DSF section. The input optical power to each span was set to be 10dBm at first. However it should be reduced to 7.5dBm for the first three spans because the signal wavelength was very near to the ZDW in these spans.

BER measurements are carried out at the end of every even span. BER at the end of the 800km line is shown in Fig.3. BER of less than 10^{-12} is achieved in all channels and BER is well balanced among channels.

Fig.3 BER of the 800km transmission.

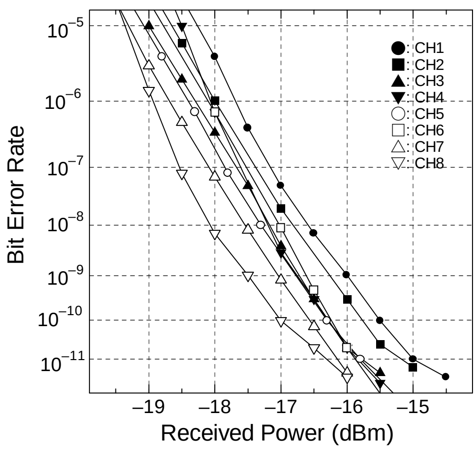
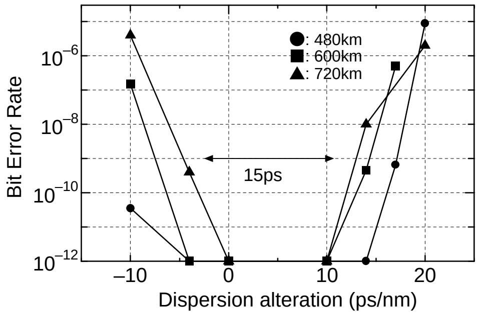


Fig.5 Dispersion tolerance.



The spectrum and the pulse forms measured after the 800km transmission is shown in Fig.4. The spectral width for the 80Gbit/s signal is 0.7nm and the small degradation is observed around the side robe compared with the spectrum at the sending end. The waveform was measured by using a streak camera for the 40Gbit/s signal that was appeared in one arm of the PBS. The pulse width marks 7.7ps.

The dispersion tolerance at distances of 480km, 600km and 720km are evaluated by measuring the BER for the same received power. The dispersion is varied at the end of the transmission line. Fig.5 shows the measured BER's. It is found that the error free condition is sustained for the dispersion change of greater than 10ps.

Summary

80Gbit/s OTDM signal transmission over 800km straight line is successfully demonstrated. The transmission line is composed of DSF with various ZDW, 80km NZ-DSF, and DCF. Usefulness of the dispersion management is shown through the experiment.

References

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