40Gbit/s (4x10Gbit/s) WDM SOLITON FIELD EXPERIMENT USING OPGW

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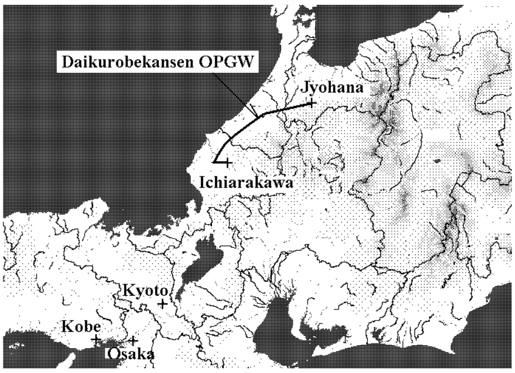
Abstract: We present soliton field experiments using dispersion-shifted fibers of the Daikurobekansen OPGW, achieved 10Gbit/s, 784km and 40Gbit/s (4x10Gbit/s), 392km transmission with 98km amplifier spacing. The result indicates good agreement with the numerical simulation.

Introduction

Many soliton field transmission experiments are reported recently /1//2//3//4/. In this paper, we show the results of single-channel and 4-channels WDM soliton field experiment using OPGW. Optical ground wire (OPGW) is placed at the top of the super high-voltage electric tower to shield the power line from lightning, and prevent power failures. Optical fibers are installed in the core of the OPGW, and exchange the information of the network operation. As multi-media societies develop, electric power companies consider the possibility to use the OPGW as a high-capacity communication network.

We investigate the transmission characteristics of soliton using the Daikurobekansen OPGW, placed between Jyohana switch station (Toyama-prefecture) and Ichiarakawa waterpower station (Fukui-prefecture). There are 8 pieces of dispersion shifted fibers in this line, and the distance is 98km. The transmission experiment up to 784km was done by turning the signals between these two points.

Fig. 1: Location of the experiment

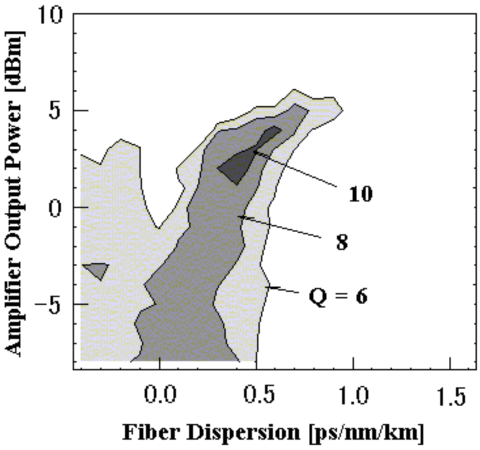


Q-map method

Q-factor contour mapping (Q-map) is a practical method to optimize the system parameters of soliton lines /5/. The mapping on the fiber average dispersion and the amplifier output power plane is useful because the balance of dispersion effects and nonlinear effects maintains solitons. The Q-factor represents the signal-to-noise ratio at the receiver decision circuit in voltage or current unit, and requires Q > 6 for the BER of 10^{-9} /6/.

Figure 2 shows the Q-map for the single-channel transmission experiment. The bit rate is 10Gbit/s, and the transmission distance is 784km with 98km amplifier spacing. From this figure, the optimal transmission is achieved at the fiber dispersion of +0.45ps/nm/km, and the signal power of +3dBm. The nonlinear Schrödinger equation is solved by the split step Fourier method. The fiber attenuation rate of 0.26dB/km, the third order dispersion of 0.073ps/nm^2/km and the sech^2-pulses of 15ps FWHM are assumed from the experimental conditions. The effective core area of 50μm^2, and Kerr coefficient of 2.24 $\times 10^{-20}$m^2/W are assumed. The amplifier noise figure is 5dB and no-filter is used in the calculation.

Fig. 2: Calculated Q-map for the 10Gbit/s single-channel transmission over 784km

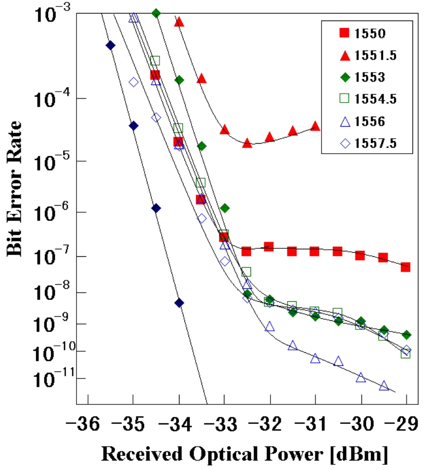


Single-channel soliton transmission experiment

In this experiment, no-dispersion management is employed, therefore the average dispersion is dominant for the transmission. We measured the average dispersions and the dispersion slopes of the fibers by the two-pulse method /9/. The zero-dispersion wavelengths of 8-fibers are distributed from 1548.8nm to 1551.1nm, and the average of them is 1550.0nm. Each fiber consists of randomly connected 51-pieces of fibers, and the average piece length is 1.9km. The zero-dispersion wavelengths are concentrated around 1550nm from the statistical effect. The average of the third order dispersion is 0.073ps/nm^2/km. We use an electroabsorption modulator (EAM) for the soliton pulse shaping, and the pulse width is 15ps.

Figure 3 shows the bit error rate (BER) characteristics measured for different wavelength single-channel 10Gbit/s pulses. The transmission distances are 784km. The average signal powers are fixed to +2dBm, and the estimations of the peak powers are +13dBm. The optimal wavelength is 1556nm, at which the chromatic dispersion value is +0.44ps/nm/km. This value is almost coincident with the prediction of the numerical simulation.

Fig. 3: BER of the 10Gbit/s, 784km single-channel soliton transmission experiment

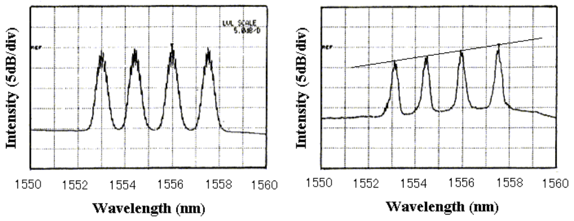


WDM soliton transmission experiment

We also executed WDM soliton transmission experiments. Figure 4 shows the spectrum of the 40Gbit/s (4x10Gbit/s) WDM soliton transmission experiment. The signal wavelengths are equally spaced 1553.0nm, 1554.5nm, 1556.0nm, and 1557.5nm. The dispersion lengths of each channel are 260km, 173km, 130km, and 104km. The initial signal powers of each channel are set to +2dBm.

The amplifier gain is sufficiently flat in the wavelength region, but the spectrum intensity is regulated according to the dispersion slope /7//8/. The intensity ratio of 1553nm to 1557.5nm is about –4dB, and the spectrum peak line passes through the zero-dispersion wavelength. The four wave mixing is completely suppressed by the dispersion fluctuation of the OPGW.

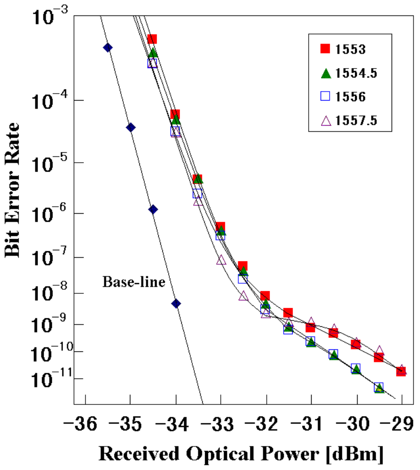
Fig. 4: Spectrum of 4x10Gbit/s WDM soliton transmission experiment. Before (a), and after 392km transmission (b).



(a) (b)

Figure 5 shows the BER performance after 392km transmission. The transmissible distance becomes half of the single-channel transmission, and the BER curves of each channel are almost overlapped. This means the nonlinear interactions between adjacent channels are dominant in the transmission performance.

Fig. 5: BER of the 4x10Gbit/s, 392km WDM soliton transmission experiment



Conclusion

We demonstrated the field experiment of single-channel and WDM soliton transmission using the OPGW. The single-channel 10Gbit/s signal was successfully transmitted over 784km, with the amplifier spacing of 98km. The optimal wavelength indicates good agreement with the numerical simulation result.

40Gbit/s (4x10Gbit/s) WDM soliton experiment was also successful over 392km transmission with same amplifier spacing. Nonlinear interactions between channels are dominant, and all channels indicate nearly same performance. The spectrum intensity regulation effect was observed.

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