A novel dispersion slope compensator for the WDM transmission system

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ABSTRACT

A new dispersion slope compensator by writing the Bragg gratings at different positions in a dispersion compensation fiber is proposed for the WDM transmission system to compensate for the accumulated dispersion of each channel.

Keywords: Dispersion slope compensator, fiber Bragg grating, wavelength division multiplexing

SUMMARY

By using the dispersion compensation fiber (DCF) [1-4] or chirped fiber Bragg grating [5], the group-velocity dispersion can be compensated and the system performance can be improved. Since the signals of different channels suffer different dispersions, a single bare DCF cannot compensate for the dispersions of all channels in an optical WDM transmission system. The dispersion slope compensator-A (DSC-A) as shown in Fig.1 was proposed[4], which divides the WDM signal channels into different DCF paths and then each channel is recombined following the individual DCFs. In this paper, we propose a new scheme of dispersion slope compensator-B (DSC-B) as shown in Fig.2. The fiber Bragg gratings (FBG) with different central frequencies, playing the role of bandpass filters, can be written at the different positions of a DCF to reflect the signals of different channels. Therefore, the signals of different channels suffer different dispersions due to their different propagating distances in the DCF. The major merits of our scheme are those the accumulated dispersions of different channels can be in-line compensated, i.e., there are no division and combining loss, and the total length of the DCFs can be greatly reduced.

In the DSC-A, some fractional energy of the signal of a channel appears in the neighboring path because of the incomplete filtering process which is due to the finite spectral side-level of the optical bandpass filter. This fractional pulse propagates in different path from the principal pulse. After the DSC the fractional pulses lead or lag behind the principal pulses and become dispersive waves. Such dispersive waves are accumulated along the transmission distance and degrade the transmssion system. We show that the dispersive waves are serious when the Fabry-Perot filters (FPF) are used. In the DSC-B, the fiber Bragg grating can be properly designed to have a rectangular-like spectrum profile to avoid imcomplete filtering. Therefore, by a proper design, the allowed transmission distance by using the DSC-B is larger than those by using the FPF or Butterworth filter (BWF) in the DSC-A. To show the dispersive waves, we use the FPF as the optical bandpass filter in the DSC-A. Fig.3 shows the normalized spectra of the WDM signals after the optical bandpass filters in path-I and path-II. In path-I, there are the principal pulse of λ_1 and the fractional pulse of λ_2 which is caused by incomplete filtering due to finite spectral side-level of the optical bandpass filter 1. In path-II, there are the principal pulse of λ_2 and the fractional pulse of λ_1 which is caused by incomplete filtering due to finite spectral side-level of the optical bandpass filter 2. The fractional pulse of λ_1, propagating in path-II with a longer DCF, has a time delay respect to the principal pulse of λ_1 in path-I. Hence the fractional pulse of λ_1 through path-II is separated from the principal pulse of λ_1 through path-I after the DSC-A. It propagates in the fiber as a dispersive wave and degrades the performance of the transmission system. The same phenomenon happens in λ_2 channel.

Fig.4 shows the Q-value versus propagation distance for λ_1 and λ_2. The bit rate is 20 Gbit/s for the single channel, the signal central wavelengths λ_1=1557.2 nm and λ_2=1560 nm, the second-order dispersions were -0.88 and -1.188 ps^2/km for λ_1 and λ_2, respectively. The allowed transmission distances are 630 km and 10080 km by using the FPF and the BWF in the DSC-A, respectively. By using the DSC-B, the allowed transmission distance is well beyond 10080 km. If the extra division and combining losses in DSC-A are considered, the performance of DSC-B is much better than DSC-A.

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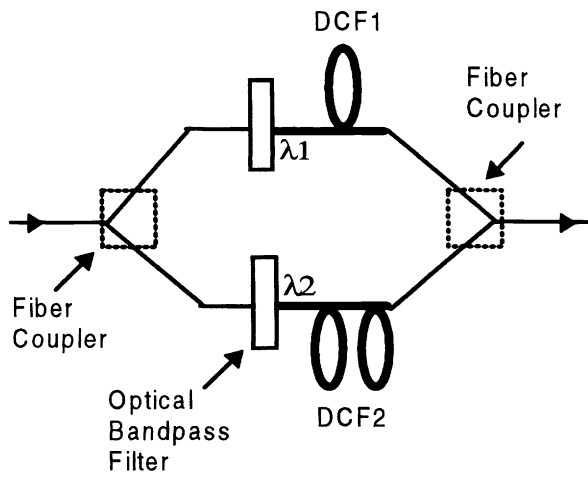
Fig.1 The dispersion slope compensator-A(DSC-A), the experimental setup of the Suzuki et al.
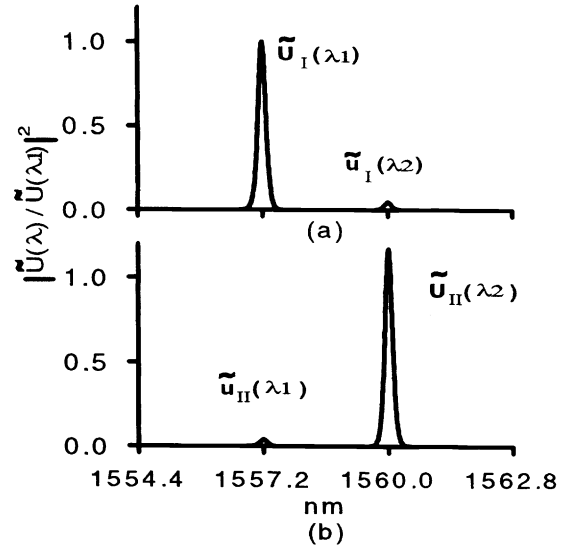
Fig.3 The normalized spectra of the WDM signals after the optical bandpass filters in (a) path-I and (b) path-II.
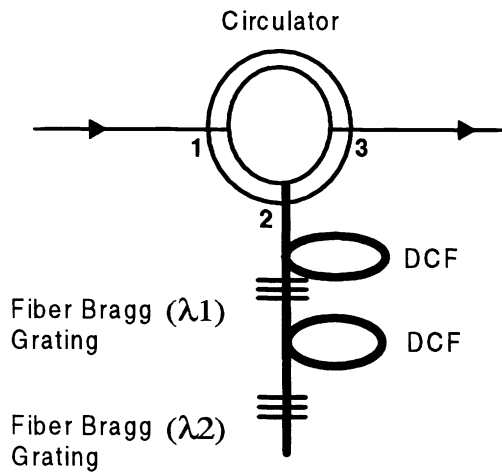
Fig.2 The dispersion slope compensator-B(DSC-B), a new scheme of the dispersion slope compensator we propose.
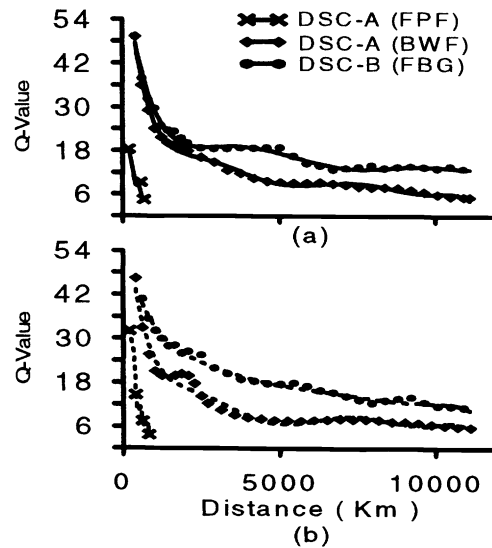
Fig.4 The Q-value versus propagation distance by using the different DSCs for (a) λ_1 and (b) λ_2.