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Dispersion Compensation and Demultiplexing Using a Cascaded CFBG Structure in a 150 km Long DWDM Optical Network

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Abstract — This paper proposes the design of a 150 km dense wavelength division multiplexed (DWDM) optical network with a capacity of 8×10 Gbps. To mitigate system dispersion, a cost-effective hybrid dispersion compensator is implemented using chirped fiber Bragg gratings (CFBG) and a pair of 5 km long dispersion compensation fibers (DCF). The novelty of the work is the use of CFBG for multiple functions, including operating as a demultiplexer and providing dispersion compensation. The proposed network design uses 140 km long conventional single-mode fiber (CSMF) and a 10 km long DCF in a symmetrical compensation mode. Without the CFBG structure, a 33 km long DCF would be needed to compensate for total channel dispersion, costing around 3$/m. However, by adding the CFBG structure, the design only requires a 10 km long DCF, reducing the DCF length by more than 65% and lowering the system cost. The CFBG integration also eliminates the need for an additional demultiplexer in the receiver section, reducing system complexity and cost. The system performance is evaluated analytically in terms of Q-factor, bit-error rate (BER), eye-diagram, and optical signal-to-noise ratio (OSNR). The average Q-factor and BER values achieved per channel are 16.5 and 8.38×10^{-56}, respectively, and for all receiver channels, the eye-openings are good enough with commendable OSNR values. The proposed design achieves good performance characteristics despite using shorter-length DCF when compared with previously reported works.

Key words — Dense Wavelength Division Multiplexing (DWDM), Dispersion Compensation, Chirped Fiber Bragg Grating (CFBG), Erbium Doped Fiber Amplifier (EDFA), Raman-scattering.

I. Introduction

Optical fiber communication (OFC), at present, is the preferred communication system because of its high transmission capacity. However, the demand for additional transmission capacity is increasing without bounds. The prime optical fiber inadequacies that limit high bit rate long-distance optical transmission are the non-linear effects, dispersion, and attenuation [1]. Although the consequences of non-linearity and attenuation are reduced by keeping the transmission power level low and using EDFA, respectively [2], dispersion is still the main criterion in restricting long-distance transmission at high bit rates [3]. For high bit rate long-distance transmission, dispersion results in inter-symbol interference (ISI) [1] and the consequences of the dispersion are cumulative with the increasing distance [4].

DWDM makes the high-capacity data rate optical transmission possible by multiplying the bandwidth of a single optical fiber [5]. The DWDM technique splits the total bandwidth of optical fiber into multiple wavelength channels and allows numerous signals to propagate through a fiber network concurrently [6]. DWDM operates in the wavelength band 1550 nm and can multiplex more than 18 channels through a single fiber.

Although DWDM increases the transmission capacity of the optical transmission system without using additional Single-mode fiber (SMF), the pulse spreading due to dispersion limits the system performance by introducing cross-talk [7] and further tightening of wavelength spacing, demanding compensation. Dispersion compensation unit (DCU) is the prime element of the long-haul optical communication network, and the most common dispersion compensation techniques use

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