Modeling of Grating Compensated Dispersion Managed Soliton Systems

Y. H. C. Kwan and P. K. A. Wai
Photonics Research Center and Department of Electronic and Information Engineering, The Hong Kong Polytechnic University, Hong Kong

Abstract:

The transmission rate and propagation distance of optical fiber communication systems are limited by channel impairments such as chromatic dispersion, intrinsic fiber nonlinearity, polarization mode dispersion, amplifier noise, etc. We focus on the methods to curtail the chromatic dispersion which result in pulse broadening. The most effective solution is dispersion management which can be applied to non-return-to-zero (NRZ) and return-to-zero (RZ) transmission formats as well as on-off and differential phase-shift keying (DPSK) modulation schemes. In 2004, through a combination of dispersion management, RZ transmission format, DPSK modulation scheme, Raman amplification, and wavelength division multiplexing techniques, the aggregate bit rate has reached the 6 tera bits per second mark for error free transmission of 6,120 km. Dispersion management is carried out by concatenation of fiber segments with different dispersion coefficients alternately such that the average dispersion is small. Another method to counter the dispersion effect is to use soliton transmission format that makes use of the intrinsic Kerr effect of optical fibers. It was discovered that soliton propagation is possible even in dispersion managed (DM) systems; they are called DM solitons.

Chirped fiber gratings (CFGs) are very attractive as dispersion compensators because of its compact size and their ability to compensate higher-order dispersion. The main drawback of using CFGs for dispersion compensation is their intrinsic group delay ripples (GDR). The GDR is formed during grating fabrication. Group delay ripple causes intersymbol interference (ISI) through the overlapping of the side peaks, generated by GDR, in the temporal pulse profiles. As a result, the transmission performance drops. In NRZ transmission, the amplitudes of the side peaks increase linearly with the number of CFGs along the transmission line.

In this work, we showed that DM solitons exist in the DM fiber systems compensated by CFGs with GDR. The use of solitons suppresses the growth of the amplitudes of the side peaks. We found that the GDR could modify the grating dispersion. The current work also includes a novel method of using nonlinear optical loop mirror (NOLM) to reduce the ISI induced by the GDR in CFG. The transmission record of grating compensated systems using the best quality CFGs is 500 km at 40 Gb/s in single channel system. Through numerical simulation, we showed that transmission systems incorporating NOLMs can achieve transoceanic propagation at the same transmission speed even in the presence of amplifier noise and random variation of GDR parameters in CFGs along the transmission line.