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ORIGINAL PAPER

Fiber Bragg grating as a sole dispersion compensation unit for a long haul optical link

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Abstract
This paper presents a comprehensive study of the Gaussian Apodized Fiber Bragg Grating (GA-FBG) as a stand-alone dispersion compensator for a 150 km long optical link. The main objective of this study is to investigate the performance of GA-FBG in various compensation modes and determine the maximum transmission distance it can support as a solo dispersion compensation unit. To achieve a more cost-effective optical link, we use the GA-FBG implementation as a substitute for the expensive Dispersion-Compensating Fiber in the network. To optimize the performance, the study explores three different compensation modes and analyses the grating parameters of the GA-FBG, taking into consideration all practical limitations of a fiber Bragg grating (FBG) in the design. The optimized links are assessed based on their performance characteristics using a Bit Error Rate analyzer. After optimizing the GA-FBG and the channel parameters of the link, the results demonstrate that the GA-FBG exhibits excellent dispersion compensation capabilities. The symmetrical compensation mode yields a remarkable *Q*-factor value, enabling transmission distances beyond 500 km with ease. Finally, to validate the functionality of the proposed system, we use the OptiSystem software. Our findings demonstrate that the GA-FBG can effectively compensate for dispersion, achieving a more cost-effective and efficient optical link with great potential for long-distance transmission.

Keywords Fiber Bragg grating (FBG) · Gaussian-apodization · Chromatic dispersion · Ultra long-haul link · Dispersion compensation

1 Introduction

Long-distance optical transmission in single-mode fibers (SMF) faces a significant obstacle in the form of chromatic dispersion, which increases with transmission length and causes inter-symbol interference (ISI) that limits high bit rates [1, 2]. Despite the fact that chromatic dispersion is zero at the Zero-Dispersion-wavelength (ZDW = 1300 nm), the 1550 nm wavelength window is preferred for optical transmission due to minimum attenuation [3, 4]. However, dispersion at the 1550 nm wavelength window still poses a major challenge [4], making it one of the primary obstacles to long-haul optical transmission in SMF.

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Two extensively adopted methods for compensating for dispersion are fiber Bragg grating (FBG) and dispersion-compensating fiber (DCF), which can be cascaded with the CSMF [4]. While previous research studies [4–8] have mainly focused on the utilization of DCF and FBG for dispersion compensation, it is concluded that DCF is more efficient than FBG. The variation in refractive index of DCF enables the faster propagation of longer wavelength components, resulting in negative dispersion [9]. Moreover, the DCF gives uniform dispersion compensation to multiple spectral components [5]. However, the length of the DCF must be increased for higher dispersion compensation in long-haul links, which leads to higher costs and restricts its application to transmissions over short distances [5]. Conversely, FBG has been shown to be less effective than DCF, although its efficacy can be enhanced by implementing appropriate chirping and apodization methods [8]. By selecting the proper grating length and chirp rate of FBG, the FBG reflects the desired passband, as reported in [10]. Hence, investigating the optimal chirping and apodization methods