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SHORT COMMUNICATION

# Cost-Effective Dispersion Compensator for Ultra-Long-Haul Optical Networks

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**Abstract** The present work aims to scale down the cost of the dispersion compensation unit (DCU) for both ultra-long-haul optical links and high-bit-rate systems. The work presents a dispersion compensator for ultra-long-haul optical links operating at a bit rate of 10Gbps. The dispersion compensator consists of a Chirped-FBG (CFBG) that supports transmission up to 600 km. Further, the designed dispersion compensator is analyzed at a higher bit rate, and a successful optical transmission of up to 100 km is achieved for a bit rate of 20Gbps. The cost of dispersion compensating fiber (DCF) is very high in comparison with CFBG, and its cost increases exponentially with increasing transmission distance. By utilizing CFBG only, the design reduces the link cost by more than 90%. Performance parameters such as Q-factor value, bit-error rate (BER), and optical signal-to-noise ratio (OSNR) are analyzed to scrutinize the proposed work. CFBG doesn't require additional amplifiers in the network due to their low loss characteristics, which reduces the complexity besides the cost of the network. Conclusively, the work has been compared to previously reported works, and the results demonstrate that the proposed approach has successfully increased the transmission length for ultra-long-haul optical links with significant cost savings.

**Keywords** Ultra-long-haul optical links · Gaussian apodization · Dispersion · OSNR · Dispersion compensation · Fiber Bragg grating (FBG)

## Introduction

Optical fiber communication has become the preferred telecommunication technique due to its numerous advantages, particularly its vast capacity and security [1, 2]. However, the issue of dispersion becomes one of the main limiting factors in optical fiber transmission [1], which results in the pulse broadening and causes the consecutive pulses to overlap, giving rise to inter-symbol interference (ISI) [2]. Dispersion also results in a reduction in the signal-to-noise ratio (SNR) and an increase in the bit error rate (BER). Moreover, the effects of dispersion are cumulative with the increasing distance [3]. Besides the data capacity, dispersion limits the propagation length [3]. Therefore, dispersion management is a critical element for service providers to utilize ultra-long-haul links in order to meet the increasing distance that bandwidth services need to travel and cater to the evolving demand for complex data services.

Prominent dispersion compensation techniques commonly used in optical networks include dispersion compensating fiber (DCF) and fiber Bragg grating (FBG) [1, 3–7]. Research studies cited in [4, 6, 7] have established that DCF is highly effective and offers uniform compensation to multiple spectral components, while also enabling upgradability to already installed links [8]. However, recent research in [9] suggests that implementing DCF in long-haul and ultra-long-haul optical networks may pose economic challenges. Furthermore, research in [10] indicates that although DCF enables the longest transmission distances, it may not be the most cost-efficient solution, which could limit the feasibility

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