Multi-carrier communication and optical fiber communication

Article Overview

Multi-carrier techniques in optical fiber communication enhance data capacity, spectral efficiency, and transmission reliability, enabling next-generation high-speed networks.

Multi-Carrier Optical Communication

Multi-carrier communication in optical systems involves splitting a high-speed data stream into multiple lower-rate subcarriers, which are transmitted simultaneously over a single optical fiber. This approach mitigates issues like chromatic dispersion, nonlinear impairments, and inter-symbol interference, which are more pronounced at ultra-high bit rates . Traditional Orthogonal Frequency Division Multiplexing (OFDM) has been widely used, but newer methods like Filter Bank Multi-Carrier (FBMC) and Universal Filter Multi-Carrier (UFMC) are gaining attention due to their improved spectral efficiency, reduced out-of-band leakage, and tolerance to synchronization errors . Digital signal processing (DSP) plays a crucial role in equalizing impairments, polarization demultiplexing, and compensating for nonlinear effects such as the Kerr effect .

Optical Fiber Communication

Optical fiber communication relies on transmitting light through fibers, traditionally single-mode fibers (SMFs), which have a single core and a theoretical capacity limit of around 100 Tbit/s . To meet the growing demand for data, multi-core fibers (MCFs) are being developed, containing multiple cores within a single fiber to increase capacity without proportionally increasing power consumption . MCFs, combined with advanced optical amplifiers, allow simultaneous amplification of all cores, reducing energy usage and enabling long-distance, high-capacity transmission . Hollow-core fibers and low-loss fibers are also being explored for long-haul multi-carrier transmission, improving tolerance to inter-modal interference .

Advantages of Multi-Carrier in Fiber Systems

o High spectral efficiency: Multiple subcarriers allow better utilization of the optical spectrum.
o Resilience to impairments: Multi-carrier systems can compensate for chromatic dispersion and nonlinearities more effectively than single-carrier systems .
o Flexibility: Techniques like FBMC and UFMC support dynamic bandwidth allocation and are compatible with advanced modulation formats .
o Scalability: When combined with multi-core fibers, multi-carrier systems can achieve terabit-per-second transmission rates, supporting future 5G and beyond networks .

Challenges and Research Directions

Despite their advantages, multi-carrier optical systems face challenges such as high peak-to-average power ratio (PAPR), computational complexity of DSP algorithms, and the need for precise synchronization . Current research focuses on:

o Reducing computational complexity of nonlinear equalization.
o Enhancing spectral efficiency while minimizing out-of-band emissions.
o Integrating multi-core fibers with multi-carrier modulation for ultra-high-capacity networks .
o Developing energy-efficient optical amplifiers for multi-core systems . In summary, multi-carrier communication combined with advanced optical fiber technologies represents a key strategy for meeting the exponential growth in data traffic, enabling high-speed, long-distance, and energy-efficient optical networks for the next generation of telecommunications.

The communication capacity limit of conventional optical fiber is being approached, and spatial multiplexing on

However, high-dimensional optical fiber systems, usually necessity bulk-optics approaches for launching different

Multicarrier modulation implementations have been approached in a number of manners, depending on how the data is

Abstract This paper proposes an efficient optical fiber communication scheme for an optical metro access network

In this paper, we will review techniques to achieve 100 Gb/s and higher optical channels; review the impact upon

Here, the authors demonstrate petabit/s transmission in a standard-sized 19-core multi-core fiber, while minimizing the

An alternate method for increasing the capacity of fiber optic communications systems is known as wavelength division multiplexing,

Optical wireless communication (OWC) is one of the trending matters in the 5G & 6G communication systems and

This chapter focuses on advancements in multi-carrier generation and large capacity optical transmission systems

In this chapter, we present an overview of multicarrier transmission and its application to optical communication, which has been in

<p>Herein, an attention-grabbing and up-to-date review related to major multiplexing techniques is presented which includes

Introduction Coherent optical communication systems have helped to keep up with the exponential growth of bandwidth

The paper reviews the development of traditional Orthogonal Frequency Division Multiplexing (OFDM) in the field of

In this way, multicarrier optical transmission methods continue to attract research attention for their versatility and flexibility to realize

Millimeter-wave carriers with high spectral purity are paramount for carrying kHz level subcarrier spacing multi-carrier signals. This

In this paper, we propose an optical semantic communication transmission system based on MMFs, as schematically

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