Application of Four New Technologies in Optical Cable Line Engineering

Overview

This article provides an overview of fiber optic technology applications in the broad field of electrical power engineering.

Key Takeaways

Four new technologies—multi-core fiber alignment, fan-in/fan-out devices, high-density optical cables, and intelligent optical network integration—are transforming optical cable line engineering by enabling higher capacity, flexible deployment, and efficient maintenance.1. Multi-Core Fiber (MCF) Alignment and Connection Technology

One of the key innovations is the automatic rotational alignment of four-core MCFs, which ensures precise alignment of the four optical cores during splicing. Since the cores are not centrally located, this technology uses side-view analysis to automatically rotate and align the cores, enabling permanent, high-precision connections both on-site and in laboratory environments. This technology is critical for interconnecting MCFs with existing single-core fibers and for rapid response to network faults, particularly in inter-data center and submarine optical transmission lines where space is limited and high capacity is required (NTT, 2024) .

2. Fan-In/Fan-Out (FIFO) Device Technology

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The FIFO device allows a single four-core MCF to connect seamlessly with four conventional single-core fibers using a two-layer quartz-based planar lightwave circuit (PLC). This technology facilitates branching and interconnection between new high-capacity MCF lines and existing optical networks, ensuring compatibility and scalability. It also supports mass production and high reliability, making it suitable for large-scale deployment in next-generation networks (NTT, 2024) .

3. High-Density Optical Cable Technology

High-density optical cables are designed to maximize fiber count within limited cable diameters. Innovations such as rollable ribbon and slot-less cable structures allow up to 2,000 four-core MCFs (8,000 cores) in a diameter of approximately 20 mm. These cables are lightweight, high-strength, and resistant to environmental damage, improving installation efficiency and reducing maintenance complexity. This technology is essential for urban deployments and data centers where space constraints are critical (NTT R&D, 2024) .

4. Intelligent Optical Network Integration

The fourth technology involves integrating optical transmission lines into intelligent, all-photonics networks (APN). This includes digital twin computing and cognitive foundation systems that optimize network resource allocation, monitor performance, and support flexible fiber deployment. By combining high-capacity MCFs with AI-driven network management, operators can expand service areas, overcome single-mode fiber limitations, and ensure low-latency, high-reliability communication for 5G/6G and future applications (NTT R&D, 2024) .

Practical Impact

Together, these four technologies enable:

• Exponential capacity increase without enlarging cable size.

• Seamless integration with existing optical networks.

• Rapid on-site deployment and maintenance, reducing downtime.

• Support for next-generation services, including ultra-high-speed data centers, 5G/6G networks, and submarine communications. These innovations collectively address the growing demand for high-capacity, flexible, and sustainable optical networks, positioning optical cable engineering to meet the challenges of future digital infrastructure (NTT, 2024; Opt-ika, 2025) .

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