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To Whom It May Concern

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Development of a New Multi-Core Fiber Connection Optical Component for Next-Generation Submarine Cable Systems

Kohoku Kogyo Co., Ltd. (Headquarters: Nagahama City, Shiga Prefecture, President and CEO: Futoshi Ishii), in collaboration with KDDI Research, Inc. (Fujimino City, Saitama Prefecture, President and CEO: Hajime Nakamura), has developed a new multi-core fiber(*1) connection optical component (fan-in/fan-out optical device (*2)) for next-generation submarine cable systems. This has contributed to the demonstration of 18,090 km optical fiber transmission, which is the greatest distance for multi-core fiber in the world.

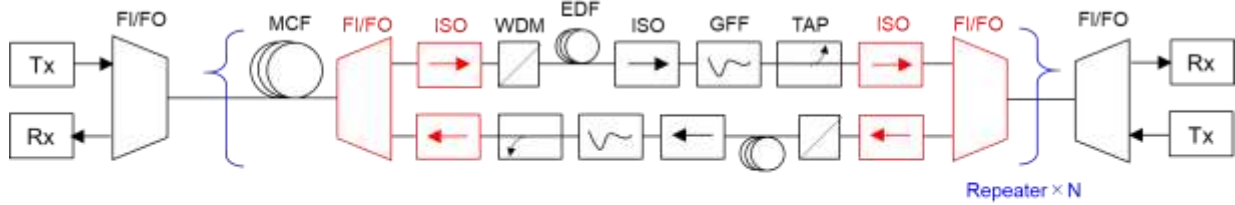
In recent years, the development of optical transmission systems using multi-core fibers has been progressing as a method to further increase the capacity of submarine cable systems. These multi-core fibers contain multiple cores within the optical fiber. In particular, two-core fibers that have the standard cladding diameter(*3) can be used to expand transmission capacity without any significant design changes from conventional transmission systems, so they expected to be the first commercial use of multi-core fibers. However, there are issues for systems that use multi-core fibers, including the suppression of inter-core crosstalk(*4) and the reduction of excessive fan-in/fan-out losses. As a result, there had not previously been any demonstration of their use for ultra-long-distance transmission at the level of transpacific communications.

In response to these issues, KDDI Research has devised an optical transmission system that suppresses crosstalk by using optical propagation in the opposite directions (counter-propagation) on each core of the two-core fiber, and also reduces excess loss by combining the fan-in/fan-out device and optical isolator(*5) built into the optical fiber amplifier(*6) (figure below). Kohoku Kogyo performed the development and prototyping of a fan-in/fan-out device to realize this new system. The device developed has a size of $\phi 12 \times 83$ mm and an isolation function that supports counter-propagation on two-core fiber. It realizes low losses, with a minimum insertion loss of 0.47 dB in the C-band (*7). The two-core fiber optical transmission system incorporating this optical device has a total transmission capacity of 29.89 Tb/s (14.94Tb/s per core) in the full C-band and was used to demonstrate the world's longest optical transmission of over 18,090 km. This result is 1.5 times the maximum distance reported so far for a system using multi-core fiber with the standard cladding diameter in C-band, which was 12,040 km (with 13.99 Tb/s per core)(*8). This shows that two-core fiber can be used at ultra-long distances across the Pacific Ocean in the same way as the conventional systems

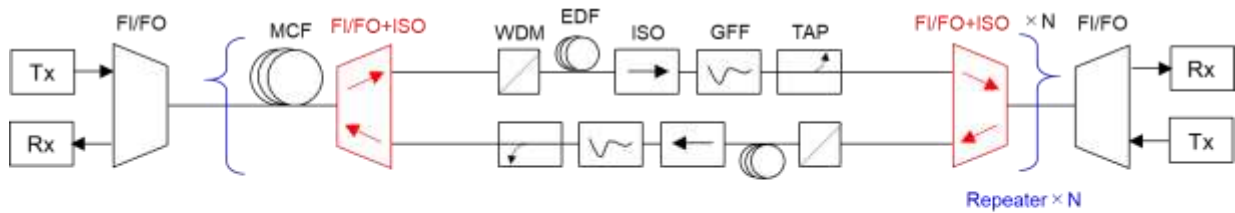
using single-core fiber (such as the trans-Pacific submarine cable Bifrost, which transmits 10.4 Tb/s over 16,460 km)(*9). It is therefore expected that the application of multi-core fibers will accelerate from now on.

The two companies announced the results of this research as a post-deadline paper at OFC2024 (held from March 24 to 28, 2024), the world's largest international conference on optical communications(*10).

<Optical transmission system using multi-core fiber (MCF) >



Counter-propagating multi-core fiber optical transmission system using representative EDFAs



Optical transmission system proposed by KDDI Research

FI/FO : Fan-in/Fan-out EDF : Erbium-doped fiber WDM : Wavelength division multiplexer
 ISO : Optical isolator GFF : Gain flattening filter



<Exterior photograph of the newly developed fan-in/fan-out optical device with an optical isolation function>

<Future outlook>

Kohoku Kogyo Co., Ltd. has been manufacturing and selling high-reliability optical components for submarine cables for many years. We are currently developing fan-in/fan-out devices, optical isolators for multi-core fiber and other new optical components that are compatible with next-generation space division multiplexing technology using multi-core fiber, which is expected to dramatically expand the transmission capacity of submarine cables and reduce their power consumption. We began shipping samples in 2024 and if everything proceeds smoothly, it is expected that mass production will begin from 2026.

< Terminology and supplementary explanations >

(1) Multi-core fiber

Unlike conventional single-core fibers, which have one path (core) along which signal light propagates, this optical fiber has multiple cores. The use of multi-core fibers makes it possible to increase the density of the signal light within a particular space, so this can be expected to increase the transmission capacity.

(2) Fan-in/fan-out optical device

An optical component that connects each core of a multi-core fiber to the core of a single-core fiber.

(3) Standard cladding diameter

An optical fiber having an outer diameter of 0.125 mm on the glass portion (cladding), as defined by international standards. The optical fibers currently used in submarine cables have a standard cladding diameter, so high mechanical reliability can also be expected for multi-core fibers if the same outer diameter is used.

(4) Inter-core crosstalk

This is an amount that represents the degree of leakage of the signal light between cores. High crosstalk causes interference in the light propagating through adjacent cores, which degrades the signal quality and reduces the transmission capacity.

(5) Optical isolator

This is an optical component that only allows light to pass in one direction. It is integrated into equipment such as submarine repeaters to suppress the destabilization of the optical amplification due to return light.

(6) Optical fiber amplifier

This is a device that amplifies a signal while it is still in the form of light, by passing the signal light through optical fibers that have rare earth added. It incorporates optical components such as optical isolators and WDM couplers. The well-known amplifiers include EDFA (erbium-doped fiber amplifiers).

(7) C-band

This is the band of wavelengths from 1530 to 1565 nm. This band has low losses in optical fibers and is commonly used in long-distance transmission systems.

(8) Source: D. Soma *et al.*, Opt. Express 30, 9482 (2022)

(9) Source: Bifrost, FCC Public Notice, SCL-00419NS (2023)

(10) Presentation at OFC2024

We presented at one of the world's largest international conferences and exhibitions in the field of optical communications (OFC: Optical Fiber Communication Conference and Exhibition). The title of the presentation was "18,090 km 2-core Fiber Transmission Using Circulatory Directional Fan-in/Fan-out Devices", Th4A.4.

<Overview of Kohoku Kogyo Co., Ltd.>

Kohoku Kogyo Co., Ltd. was founded in 1959 as a manufacturer of lead terminals for aluminum electrolytic capacitors and went on to enter the optical components and devices business in 2000. Today, 53% of our sales are in the lead terminal business and 47% are in the optical components and devices business. In the optical components and devices business, we take a 50% market share in the optical isolator market for submarine cables, making us the leading company in this field. As a third area of growth business, we are also advancing the commercialization of high-purity quartz glass made using the slurry casting method.

<Inquiries related to this news release>

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