FOR IMMEDIATE RELEASE

Signal processing technology for long-distance optical fiber communication with 16-level optical multi-level signal using commercial semiconductor lasers

Tokyo, Japan, 20th September 2011 – Hitachi, Ltd. (NYSE: HIT/TSE: 6501, hereafter, Hitachi) today announced the development of a novel signal processing technique for the realization of the next-generation high-speed long-distance optical fiber communication networks with four times capacity using multilevel transmission as 16 signal levels.

Recently, much attention has been focused on coherent optical multilevel transmission[*1] in order to increase the capacity of next-generation long-distance fiber networks. Several higher-order multilevel transmission experiments have been demonstrated so far using lab-grade lasers that are high in quality but very expensive. The use of inexpensive commercial lasers is preferable for the development of practical and economical multilevel transmission systems, but their rather high phase noise[*2] easily degrades the quality of densely packed, higher-order multilevel signals. Hence, Hitachi has developed a new signal processing technique to suppress the phase noise and enable the use of commercial-grade semiconductor lasers in 16-level or higher multilevel transmissions. This technique was applied in an 80-Gbit/s 16-level multilevel transmission experiment over 320-km-long optical fiber using commercial semiconductor lasers without noticeable degradation.

The solid growth of Internet data traffic is driving the increase in capacity of core (inter-city) and metro (intra-city) optical fiber networks. Conventionally, wavelength division multiplexing (WDM) techniques[*3] using several different laser waves have been utilized to bring optical fiber networks to full capacity. To further increase the transmission capacity several times, advanced transmission techniques such as polarization division multiplexing (PDM)[*4] and optical multilevel transmission, are under serious consideration for practical use. The optical multilevel transmission technique conveys several information bits at once by jointly changing (or modulating) the amplitude and the phase[*5] of the optical signal. For example, modulation of the signal phase into four distinct angles with 90-degree spacing results in four-level phase modulation, conveying two information bits (2^2=4 states) at once. Further application of

-more-

PDM, i.e., the use of two laser waves vibrating in horizontal and vertical planes, doubles the transmission capacity, resulting in a total of four information bits. The next-generation 100-Gbit/s long-distance optical fiber transmission systems currently under development are intended to use a combination of such four-level optical multilevel transmission and PDM techniques. However, as the number of signal levels increases to 16, 32, or more, the spacing of each signal level in the optical phase becomes smaller and smaller. Therefore, inexpensive commercial lasers with large phase noise cannot be used for fiber transmission experiments with such higher-order multilevel signals, and expensive high-quality lasers are typically utilized, instead.

To overcome this problem, Hitachi has developed a new digital signal processing technique that improves the performance of coherent optical multilevel transmission, which enables the use of commercial semiconductor lasers. The details are given below.

(1) Digital delay-detection technique to suppress phase noise

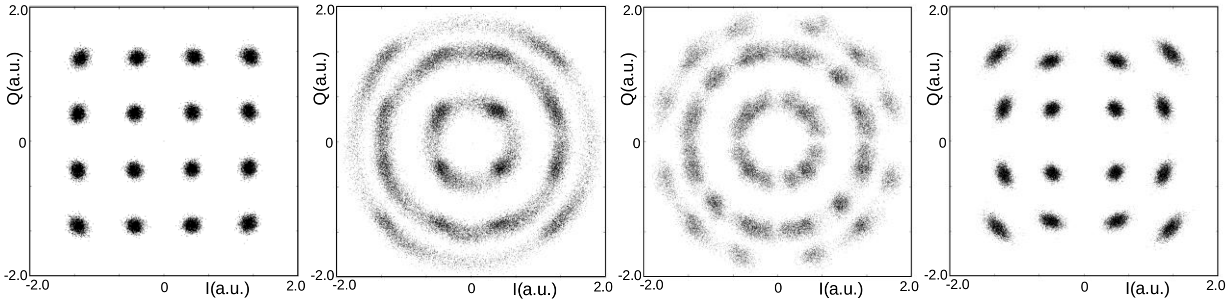
Two multilevel signals subsequently received in time have almost the same amount of phase noise in common; the phase noise can be reduced by subtracting the phases of the two received signals. Therefore, after converting the received 16-level optical signals to digital electrical signals, a digital delay-detection circuit is introduced, which subtracts the phase of the previously received signal from the current one, leaving the signal amplitude intact. By doing so, the phase noise is reduced, and the quality of the received multilevel signal is improved.

(2) Digital phase-summation technique to suppress the disorientation of multilevel signals

An unwanted side effect of the digital-delay detection circuit, i.e., the phase subtraction circuit, is that it causes disorientation of received signals, which hinders its application to complex multilevel signals like the 16-level signals discussed here. To avoid this disorientation, a digital phase-summation circuit is introduced at the transmitter-side electrical signal processing part, which sums up the phases of transmitted multilevel signals prior to converting them to optical signals. The phase-summation effect exactly cancels out the phase-subtracting effect of the receiver-side digital delay-detection circuit, which eliminates the signal disorientation.

Hitachi utilized the proposed digital delay-detection and phase-summation techniques in an 80-Gbit/s optical 16-level transmission experiment over 320-km fiber with commercial-grade semiconductor lasers and succeeded in transmitting high-quality signals. Hitachi will apply these techniques to the development of future ultra-high-speed optical fiber communication systems at 400 Gbit/s or beyond.

These results will be presented at the 37th European Conference on Optical Communication (ECOC 2011) held from 18–22 September, in Geneva, Switzerland.



(a) Conventional method with high-quality laser diode

(b) Conventional method with commercial laser diode

(c) (b) applying only digital delay detection

(d) Proposed method: Digital-delay detection and phase addition with commercial lasers

Fig. 1 Received 16-level signals (X polarization)

Notes

*1. Coherent optical multi-level transmission: High-capacity transmission techniques carrying several information bits at once using several different states of a light wave, combining optical phase and amplitude.

*2. Phase noise: Timing fluctuation of a light wave. The phase noise degrades the transmission quality of multi-level signals and induces data errors. In coherent optical multi-level transmission, the phase noise typically comes from inexpensive laser diodes or from the fiber non-linear effect, and is known to seriously degrade the signal quality.

*3. Wavelength division multiplexing (WDM): A high-capacity fiber transmission technique transmitting several optical signals with slightly different wavelengths at the same time in a single optical fiber.

*4. Polarization division multiplexing (PDM): Another high-capacity fiber transmission technique using two orthogonal optical signals vibrating in horizontal and vertical planes, carrying different information, to double the transmission capacity of a single optical fiber.

*5. Optical phase: The timing delay of an optical wave, represented in angles from 0 to 360 degrees. The 0-degree phase represents an optical wave with zero delay, and the 180-degree phase corresponds to the half-cycle delay.

About Hitachi, Ltd.

Hitachi, Ltd., (NYSE: HIT / TSE: 6501), headquartered in Tokyo, Japan, is a leading global electronics company with approximately 360,000 employees worldwide. Fiscal 2010 (ended March 31, 2011) consolidated revenues totaled 9,315 billion yen ($112.2 billion). Hitachi will focus more than ever on the Social Innovation Business, which includes information and telecommunication systems, power systems, environmental, industrial and transportation systems, and social and urban systems, as well as the sophisticated materials and key devices that support them. For more information on Hitachi, please visit the company's website at http://www.hitachi.com.

# # #