

100km Transmission of Dispersion-Compensation-Free, Extended-Reach OCDMA-PON System with Passive Remote Node

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Abstract-- In an extended-reach OCDMA-PON system with passive remote node, 10-Gbps x 4-user, OCDMA transmission over 100-km standard SMF using a single multi-port encoder/decoder without inline dispersion compensation is successfully demonstrated.

I. INTRODUCTION

Gigabit-class fiber-to-the-home (FTTH) service is required to meet the demands of future high bit rate applications such as uncompressed 1.2-Gb/s high-definition (HDTV) class or even 6-Gb/s 4K digital cinema on a peer-to-peer basis as well as medical applications of teleradiology and surgery. Optical code division multiple access (OCDMA) is one promising candidate for the next generation FTTH system [1]. It has unique features of full asynchronous transmission, low latency access, soft capacity on demand as well as optical layer security [1]. Recently, for the coherent time-spreading (TS-) OCDMA, the multi-port OCDMA encoder/decoder (E/D) has the unique capability of simultaneously processing multiple time-spread optical codes (OCs) with single device, which makes it a potential cost-effective device to be used in the optical line terminal (OLT) of an OCDMA network to reduce the number of E/Ds [2]. Very recently, we have proposed a dispersion-compensation-free, extended-reach, OCDMA-PON system, which deploys a passive remote node (RN) with a single multi-port E/D between the OLT and optical network units (ONUs), by tailoring OC spectrum [3]. An RN architecture allows to eliminate E/D at each ONU.

In this paper, we demonstrate the dispersion-compensation-free, extended-reach, OCDMA-PON system. 10 Gbps, 4-user, OCDMA transmission is successfully demonstrated over 100 km of the SSMF without inline dispersion compensation by optimized the OC spectrum.

II. ARCHITECTURE OF EXTENDED-REACH OCDMA-PON SYSTEM

Fig. 1 shows the architecture of the dispersion-compensation-free, extended-reach, OCDMA-PON system. A RN with single multi-port E/D and the narrow band optical band pass filter (NB-OBPF) is deployed between OLT and ONUs instead of an optical passive splitter. It is used as a decoder and splitter for the

downlink and as an encoder and combiner for the uplink. Therefore, each ONU does not need any E/Ds. It can reduce costs and devices compared with the conventional one. In downlink, each signal is encoded by the multi-port. The spectrum of encoded signals is tailored by using NB-OBPF to decrease the chromatic dispersion effect [4]. Therefore, encoded signals can be transmitted over a trunk span and decoded at an RN. Furthermore, each decoded signal is transmitted over an access span and received by each ONU. In the demonstration, we use 16-chip, 16-level phase-shifted OCs, which correspond to the OCs generated from the 16x16-port encoder with input 1, 5, 9, 13 ports, output port 8, respectively. The duration of the generated OCs is ~80 ps (chip-rate: 200 Gchip/s). In other words, each OC has 200 GHz (1.6 nm) spacing spectrum component. To solve this issue, we employ a rectangular shape OBPF of 1.6 nm bandwidth after the encoder to extract only one spectrum component from OC to reduce the chromatic dispersion effect.

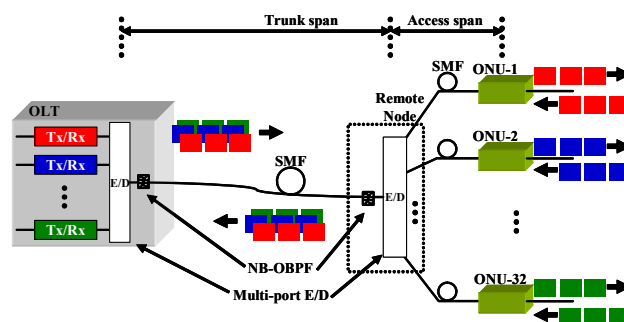


Fig. 1. Architecture of extended-reach OCDMA-PON system.

III. EXPERIMENTS

Fig. 2 shows the experimental setup and results of the extended-reach OCDMA-PON system. A mode-locked laser diode (MLLD) generated 2.4 ps optical pulses at the repetition rate of 10.3125 GHz with the central wavelength of 1551 nm as shown in Fig. 2 (a). The generated signal was modulated by a LiNbO₃ intensity modulator (LN-IM) as shown in Fig. 2 (b). The frame contains 2³¹-1 pseudo random bit sequence (PRBS) payload. The generated data was split into 4 branches in a truly-asynchronous manner with equal power, random delay, and random bit phase, and launched into the multi-port encoder, which generates 16-chip (200 Gchip/s), 16-level-phase-shifted OCs as shown in Fig. 2 (c). For investigating the system performance in the worst

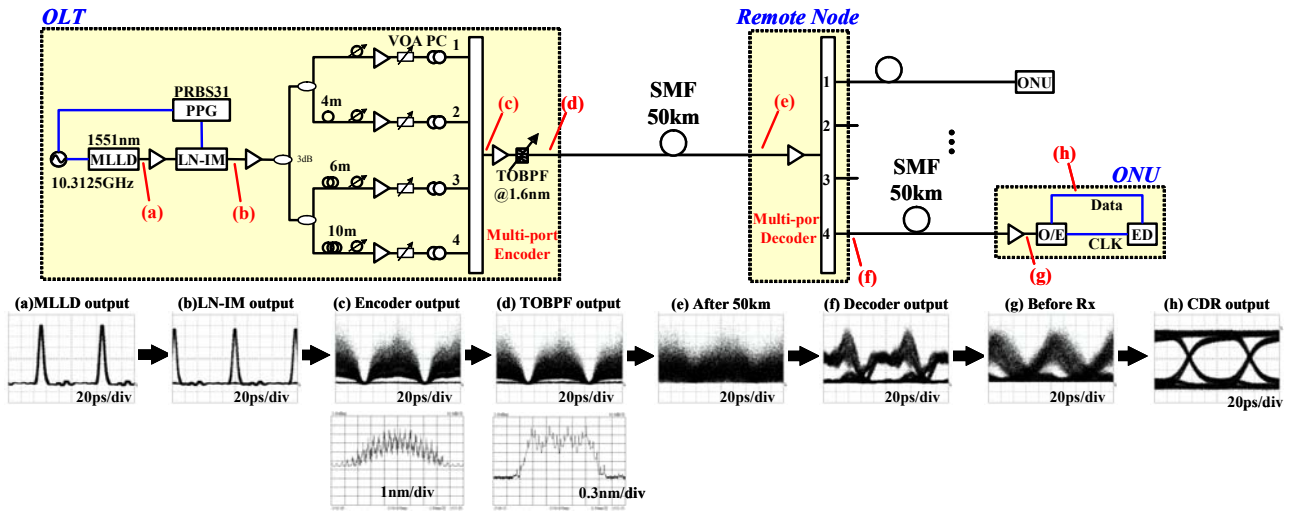


Fig. 2. Experimental setup and results.

scenario where the interference becomes most serious, polarization controllers (PCs) were placed to align the polarization states of all the signals. These 4 signals were multiplexed and then passed through a tunable OBP (TOBPF) of 1.6 nm bandwidth (Alnair Labs.: BVF-100) as shown in Fig. 2 (d). These OCDMA signals were launched into 50 km SSMF as shown in Fig. 2 (e). After the SSMF transmission, these OCDMA signals were decoded by the multi-port decoder, which has the same configuration of the multi-port encoder, at the RN as shown in Fig. 2 (f). The decoded signal was then transmitted and detected by the optical/electrical converter and clock-and-data-recovery circuit (CDR) at each ONU. Figures 2 (g) and (h) show the waveform of 50 km SSMF transmission and CDR output.

Fig. 3 (a) shows the measured total chromatic dispersions of the 50 (trunk span) and 50 km (access spans) SSMFs, respectively. The total chromatic dispersion at 1551 nm is around 1749 ps/nm in case of 100 km. Fig. 3 (b) shows the measured BERs. In these

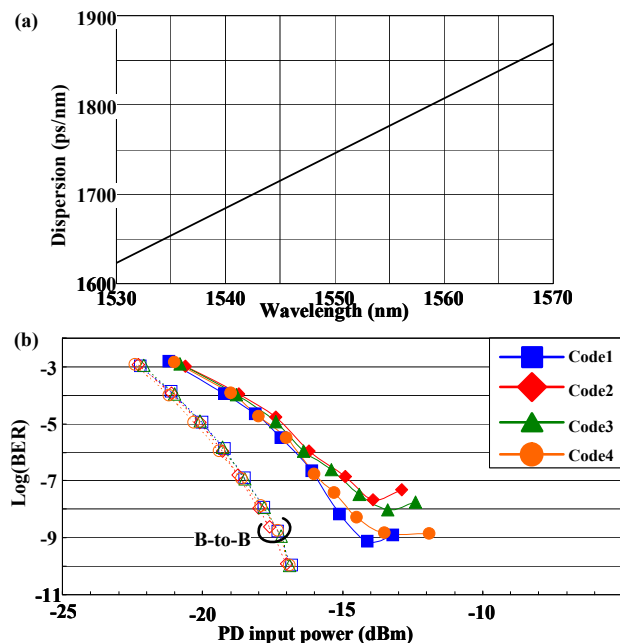


Fig. 3. Measured (a) total dispersion and (b) BERs.

figures, solid and dashed lines show 100 km SSMF transmission and B-to-B results, respectively. All data can realize error-free ($BER < 10^{-3}$) operation with the forward error correction (FEC) as RS (255, 223). Please note that the use of FEC at 10Gb/s in FTTH systems will likely become a real-world scenario because of the low-cost [5]. BER of less than 10^{-7} could be achieved by tailoring OC spectrum.

IV. CONCLUSIONS

We have demonstrated the dispersion-compensation-free, extended-reach, OCDMA-PON system. 10 Gbps, 4-user, OCDMA transmission has been successfully demonstrated over 100 km of the SSMF without inline dispersion compensation by optimized the OC spectrum.

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