Lightwave Centralized WDM-OFDM-PON

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Abstract

We have proposed and experimentally demonstrated, for the first time, a novel WDM-OFDM-PON using centralized lightwave to provide downstream 16-QAM phase-modulated OFDM signals at 10Gbit/s and upstream OOK at 1.75Gbit/s.

1. Introduction

Recently, the research and development is being focused on the next generation PON access networks, such as time division multiplexing PON (TDM-PON) and wavelength division multiplexing passive optical network (WDM-PON) [1-2]. However, TDM-PON systems need complex scheduling algorithms and framing technology to support different applications. WDM-PON still lacks the flexibility to dynamically allocate the bandwidth among the optical network units (ONUs), which is a promising approach to meet the requirements of future access networks. For signal generation, there are many modulation formats, such as on-off keying (OOK), differential phase-shift keying (DPSK) and so on. However, orthogonal frequency division multiplexing (OFDM) is an effective modulation format which has recently received much attention for the use in fiber-optic transmission systems because of its high spectrum efficiency and the resistance to variety dispersions including chromatic dispersion (CD) [3-4]. Recently, we had proposed a 10Gbit/s OFDM-PON to transparently support various services and enable dynamic bandwidth allocation among these services [5]. But, there is no upstream link demonstration. Direct-detection optical OFDM, compared with the traditional coherent detection, can significantly simplify the system complexity and eliminate the phase noise and frequency offset [6]. In this paper,

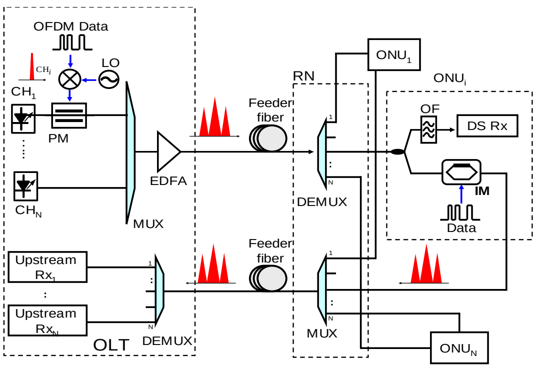

Figure 1: Proposed centralized WDM-OFDM-PON architecture. PM: phase modulator, LO: local oscillator, IM: intensity modulator, OF: optical filter, DS Rx: downstream receiver.

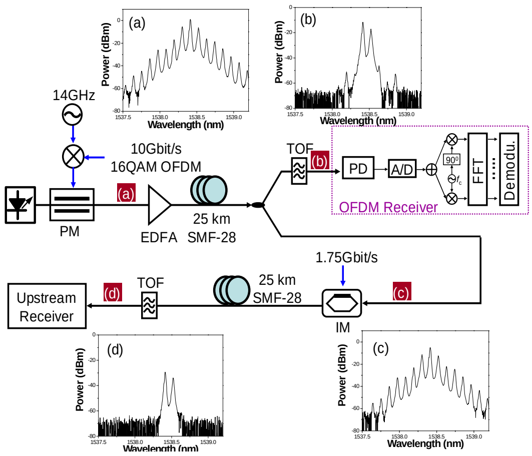

Figure 2: Experimental setup and the received optical spectra with 0.01nm resolution.

we proposed and experimentally demonstrated a novel WDM-OFDM- PON architecture with centralized lightwave. Downstream signal with 10Gbit/s phase modulated 16QAM OFDM and upstream signal with 1.75Gbit/s OOK signal has been demonstrated.

2. Proposed Architecture

The principle of the proposed architecture is illustrated in Fig. 1. The optical line terminal (OLT) designed consists of *N* distributed laser source. One phase modulator (PM) is employed to generate phase modulated signals with constant optical power for WDM-OFDM downstream transmission. OFDM baseband signals are up-converted to a high RF carrier by an electrical mixer with a RF source. The power of RF OFDM signal has to be carefully adjusted to maintain a certain power ratio between LO and first-order sidebands while suppresses the second-order modes to increase dispersion tolerance and good receiver sensitivity. In the remote node (RN), one DEMUX is used to separate channels and deliver to each optical network unit (ONU). The downstream signals are sent to two paths after passing through a 3dB coupler. One part is fed to an OFDM receiver after passing through one narrowband optical filter. This optical filter is used to convert the phase signal to intensity signal. For upstream link, the phase modulated downstream OFDM signal is re-modulated by an intensity

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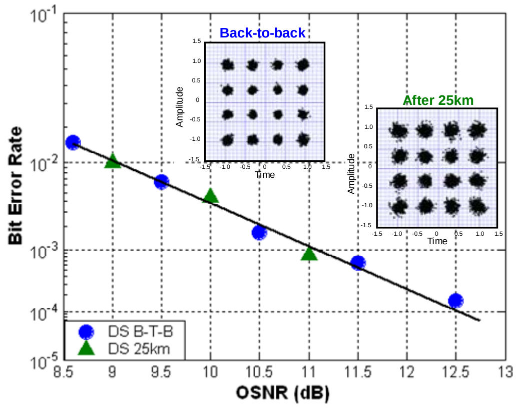

Figure 3: Measured BER curves and the corresponding constellation for 16-QAM phase-modulated OFDM signals at 10Gbit/s

modulator (IM). Consequently, the centralized lightwaves is realized because there is no any lightwave source in the ONU.

3. Experimental Setup and Results

The experimental configuration is displayed in Fig. 2. In central office (CO), one CW lightwave was generated by a DFB laser at 1538.35nm. An OFDM baseband signal was generated offline and uploaded into a Tektronix AWG 7102 arbitrary waveform generator (AWG). The waveforms produced by the AWG were continuously output at 10Gsample/s and 10-bits DAC and the output bandwidth was 5GHz based on the Nyquist law. The 16QAM OFDM signals at 10Gbit/s are mixed with a 14GHz sinusoidal wave by a mixer. The mixed RF signal after amplification was driven a PM. The optical spectrum with 0.01nm resolution after the phase modulator is shown in Fig. 2 as inset (a). After 25km SMF-28 transmission, the separated downstream traffic was divided into two parts by a 3dB optical coupler. One part is delivered to downstream OFDM receiver, and the other part is prepared for upstream signals. At the downstream receiver, WDM-OFDM signal was filtered by a tunable optical filter (TOF) with a bandwidth of 0.2nm. The received RF OFDM signal was sampled by a Tektronix real-time after a 45GHz photo-detector. The digital signal processing work was done off-line. For upstream link, the RF OFDM signal was re-modulated by an IM at 1.75Gbit/s with PRBS of 2^{31}-1. Fig. 2 (b)-(d) shows the optical spectrum for downstream, before re-modulation, and upstream receiver, respectively. The BER curves as a function of OSNR (0.1 nm reference bandwidth) and the corresponding constellations of downstream OFDM signals are exhibited in Fig. 3. We can see that the required OSNR at 1e-3 is 11dB after 25km transmission. There is no obvious OSNR power penalty after transmission. Fig. 4 illustrates the measured BER curves and the corresponding eye diagrams for upstream transmission. It can be seen clearly from

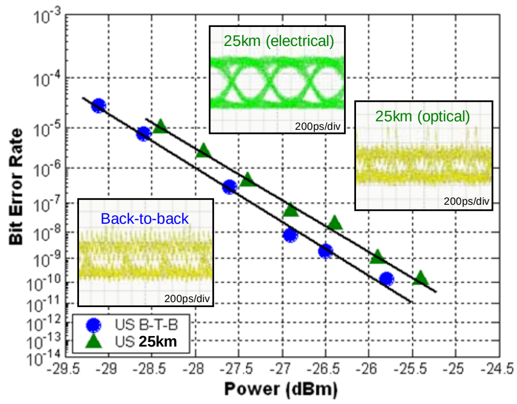

Figure 4: Measured BER curves and the corresponding eye diagrams of back-to-back and after 25km SMF for 1.75Gb/s upstream signal.

the eye diagram of back-to-back, the 1.75Gbit/s upstream signal is carried with the clock of 14GHz. The high-frequency components will be removed at the receiver with a 2GHz low-pass filter. The power penalty is less than 0.5dB after 25km of transmission, which is resulted from the fading effects of DSB signals.

4. Conclusions

We have proposed a novel WDM-OFDM-PON transmission system with centralized lightwave. It is the first time, in our best knowledge, to realize centralized lightwaves in OFDM-PON systems with direct detection. Using this scheme, downstream 16QAM phase modulated OFDM at 10Gbit/s has been transmitted over 25km SMF-28 fiber without OSNR penalty. For upstream link, downstream signals were re-modulated by an IM at 1.75Gbit/s. The power penalty is less than 0.5dB for upstream channels after transmission. Because OFDM is an effective modulation format for next generation optical network, this proposed scheme can provide significant improvement on both system reliability and flexibility.

Acknowledgements

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5. References

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