WDM-PON using ASK modulation with polarization multiplexing

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***Abstract*—We propose and experimentally demonstrate bidirectional transmission of signal in WDM-PON using Amplitude Shift Keying (ASK) modulation based on a novel polarization multiplexing approach. Polarizing beam splitter (PBS) is used for regulating extinction ratio (ER) and achieving good optical signal-to-noise ratio (SNR) for signal transmission.**

Keywords- ASK; PBS;WDM

I. INTRODUCTION

Wavelength-division-multiplexed passive optical network (WDM-PON) is widely considered as a key technology for high-speed next-generation access networks. Several ways of upstream re-modulation in WDM-PON are introduced to design their architectures with a "colorless" (non-wavelength-specific) and "sourceless" optical network unit (ONU) [1-6]. In this article a novel approach based on polarization multiplexing is proposed. This approach can use simple Amplitude Shift Keying (ASK) modulation in both downlink and uplink with good system performance.

Light extinction ratio (ER) of downstream transmission is a key parameter determining not only optical signal-to-noise ratio (SNR) of downstream transmission but also SNR of upstream transmission. We propose a new way for ER adjustment by polarization multiplexing. A polarizing beam splitter (PBS) divides the continuous-wave (CW) into two orthogonally polarized components. We just modulate data upon one light component, and make the two components incoherent. The downstream signal from the transmitter contains two signals without interference. So we can adjust ER flexibly by controlling polarization direction from the light source of laser diode (LD) .

II. PRINCIPLE

Fig1 shows the principle diagram of bidirectional ASK modulation in WDM-PON. A distributed feed-back laser diode (LD) is employed as continuous-wave (CW) light source. The CW is divided into two polarization components by PBS. A series of Mach-Zehnder Modulators (MZM) are driven by downlink data signal. The output signal of each transmitter (TX) which has two components with orthogonal polarizations is combined in an arrayed waveguide grating (AWG). After transmission in optical fiber, each signal is picked up by the destination receiver (RX) through AWG.

This work was partially supported by the Science and Technology Department of Zhejiang Province (grant No. 2008C21090)

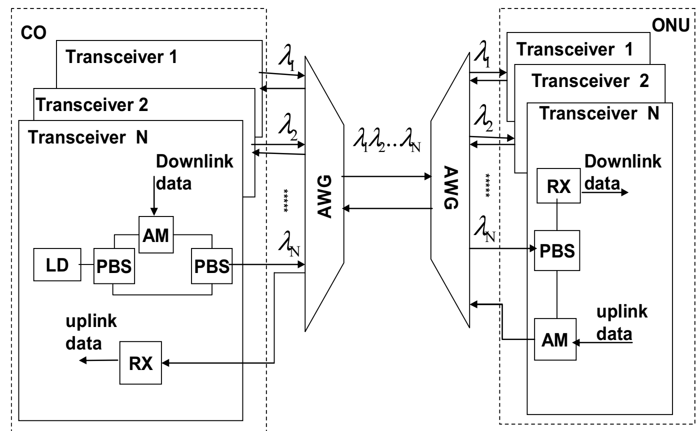

Figure 1. WDM-PON using ASK modulation with polarization adjustment (LD: laser diode, PBS: polarizing beam splitter, AM: amplitude modulation, SMF: single-mode fiber, AWG: arrayed waveguide grating)

The PBS in front of RX picks up modulated signal of downlink data, and passes CW to MZM for uplink data modulation.

Fig2 shows the modulation schematic of MZM. The ER of ASK format can be adjusted by controlling the bias voltage of the driver signal. We can define b1, b2 as the data'1','0'. The further distance between b1 and b2, the better ER and eye diagram opening. But the limitations in ER and noise of bias voltage have some influence on eye diagram, especially when b1 and b2 get close. So we propose a solution by polarization multiplexing: utilize PBS to divide CW into two polarization

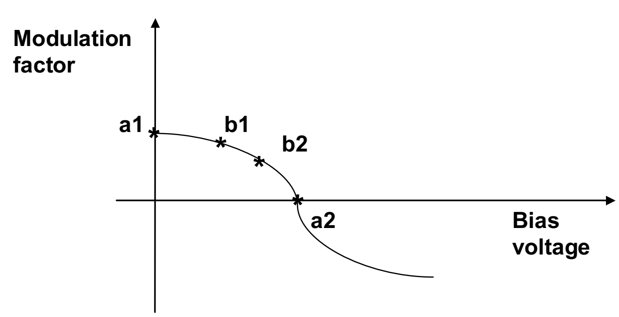

Figure 2. modulation curve of MZM (b1, b2 and a1, a2 are two groups standing for signal '1', '0' in different ER)

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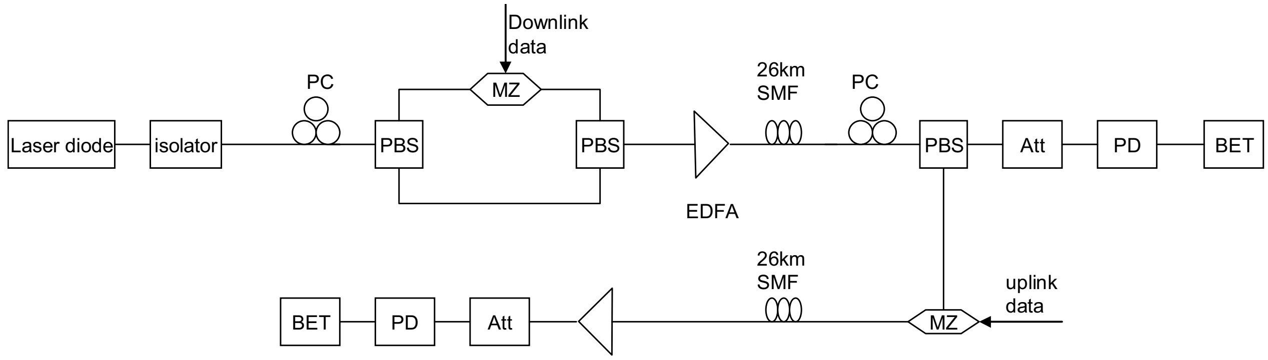

Figure 3. experiment setup (PC: polarization controller, EDFA: Erbium-doped fiber amplifiers, Att: variable optical attenuator, PD: photo detector)

components and just modulate one component for downlink data in one line. We can fix the bias voltage at better performance of eye diagram (selecting a1 and a2 for example). Then ER is depending on the ratio of output intensity in two components, which is adjustable by controlling the polarization of CW before entering PBS. In this solution, ER has no confliction on modulation depth of MZM and the quality of downstream eye diagram gets improved.

After transmission over fiber, a PBS in receiver is used to separate the CW from downlink data for upstream re-modulation. The modulated signal is sent to RX at ONU. The clean CW, without residual noise caused by downlink modulation, is reused and transmitted back after uplink data modulation.

III. Experiment results

Fig 3 shows the experimental setup using ASK modulation. To generate the optical ASK modulated downlink signal, we use a tunable laser (TL) tuned at 1551nm and with 1MHz bandwidth. An isolator is used to prevent the damage to light source. A couple of "PC and PBS" can divide the CW into two polarization components with arbitrary power (intensity) ratio. The optical modulation depth of the ASK signal is set to 0.33 here, which is proved to be suitable in the experiment for achieving good signal to noise ratio in both transmission directions. The ASK downlink data, with a non-return-to-zero (NRZ) pseudo-random binary signal (PRBS) with length of , rated at 10Gbit/s, is imposed into the MZM. The downlink signal is amplified by Erbium-doped fiber amplifiers (EDFA) with about 10 dBm and then transmitted through 26 km SMF link to the receiver. Another couple of "PC and PBS" used in receiver to separate the downlink signal and the CW. After optical to electrical conversion with a photo detector (PD) following the attenuator, performance of the downlink signal is measured by BER tester. The CW separated from PBS is re-modulated by ASK uplink data signal in MZM. We also use a NRZ PRBS rated at 2.5Gbit/s as the uplink data, and optimize the modulation depth of ASK uplink signal. The uplink data is then transmitted back through 26km SMF and measured in the same way. Another EDFA in uplink receiver is used to increase power for detection and BER evaluation.

The BER performance of 10Gbit/s downlink signal and 2.5Gbit/s uplink signal is showed in Fig 4. For the downlink signal, at the output of the attenuator, there is almost no power penalty between the back-to-back and the signal after 26km SMF transmission. About 0.8dB power penalty is detected between the back-to-back and the uplink signal after 26km SMF transmission. We also show the stable and clean eye diagrams of the received downlink and uplink signal in Fig 4.

IV. Conclusion

We have proposed and experimentally demonstrated a novel bidirectional transmission system over 26km SMF in WDM-PON using ASK modulation. Polarization multiplexing has been adopted for adjustment of ER. The system performance is good. The experiment results suggest that it is feasible to realize such a cost-effective WDM-PON system.

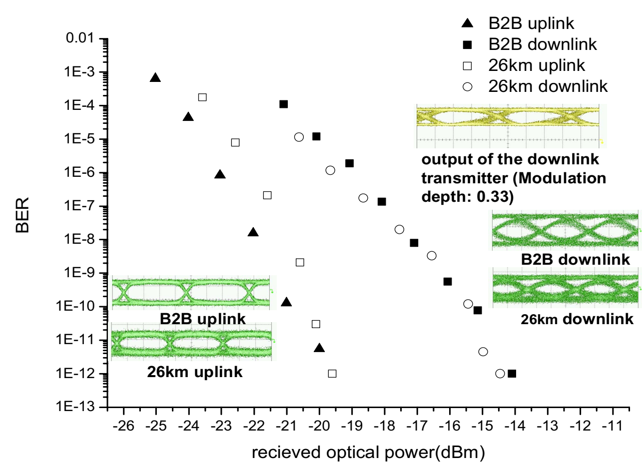

Figure 4. BER measurements and Eye diagrams of the signals

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