A Novel Time-interleaved Phase Remodulation Scheme in WDM-PON with Enhanced Tolerance to Rayleigh Backscattering

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Abstract[1]

A novel time-interleaved DPSK remodulation scheme in WDM-PON is proposed in this paper. Downstream and upstream signals achieved error-free performance at 5-Gb/s with negligible penalty and enhanced tolerance to Rayleigh backscattering (RBS).

1. Introduction

Remodulation in wavelength-devision-multiplexing passive optical network (WDM-PON) systems has attracted vast interests as a cost-effective optical network unit (ONU) solution without dedicated light sources for upstream signals for providing high-speed symmetric capacity in PON. Various remodulation approaches have been proposed to achieve robust performance of both downstream and upstream transmissions [1-3]. Novel devices such as reflective SOA (RSOA) with high data rate operation up to 10Gb/s [1] as well as new remodulation formats [2-3] were introduced. In [2], reduced modulation depth DPSK (RMD-DPSK) was proposed with enhanced tolerance to chromatic dispersion and Rayleigh backscattering (RBS) in single fiber transmission. Subcarrier remodulation was utilized in [3] to separate the spectrums of reflected noise and upstream signal.

In this paper we propose a novel phase remodulation scheme which demonstrates enhanced RBS tolerance by introducing time-interleaving between downstream and upstream signals. No additional light sources are needed at ONU and negligible distortion is measured on both signals after bidirectional transmission.

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2. Operation Principle

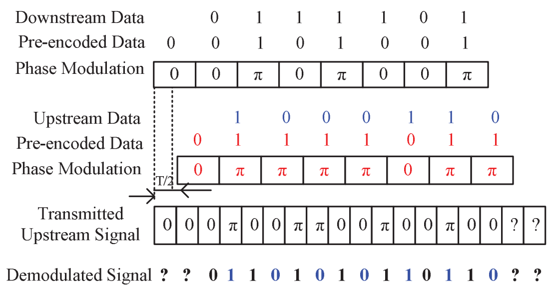


Fig.1. Illustration of time-interleaved phase remodulation.

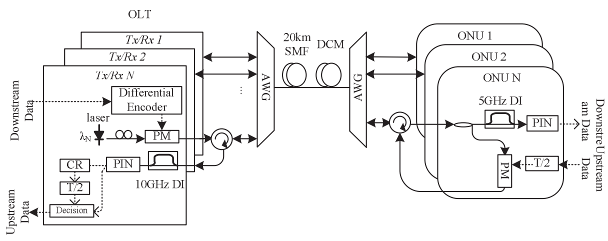


Fig.2. Proposed WDM-PON remodulation scheme.

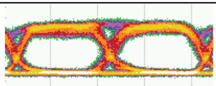
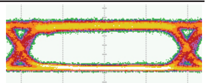
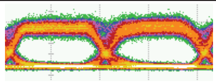
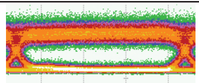
Fig.1 illustrates operation principle of the proposed remodulation scheme. After *T/2* offset of upstream and downstream signals, where *T* is the bit period, an XOR operation is applied on the two independent phase modulated patterns [4] and the phase difference between the leading half of a bit in the upstream DPSK signal and the trailing half of the previous bit will not be affected by the original phase modulation of the upstream data [5]. By using a half-bit-delay differential interferometer (DI) at OLT, the received upstream signal can be simply demodulated and the upstream data can be correctly detected on trailing half bits of the demodulated signal.

3. Experiments and Results

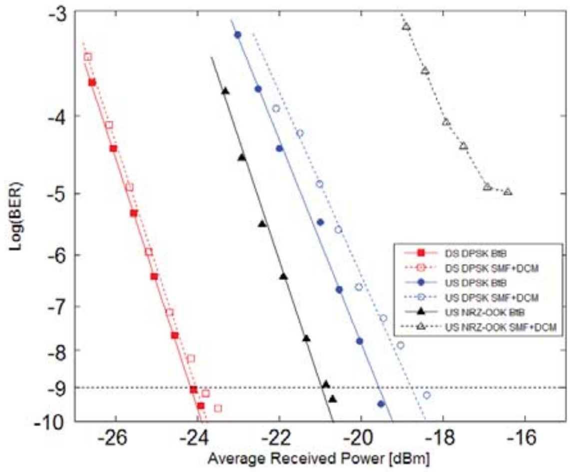
Fig.2 shows the system architecture of the proposed remodulation scheme. A 5-Gb/s 2^{31}-1 pseudorandom binary sequence (PRBS) downstream data was modulated on a CW laser light source at 1552.4 nm via an optical phase modulator (PM) with driving voltage of ~V_{π}. The modulated optical signal was fed into 20-km single mode fiber (SMF) after propagating through an optical circulator and a 100-GHz AWG (insertion loss = 4 dB, 3-dB bandwidth = 0.6 nm). A dispersion compensation module (DCM) followed the feeder fiber to isolate the effect of chromatic dispersion. At ONU, a 3-dB coupler split the received downstream signal with one portion for demodulation and detection, while the rest of power was remodulated with upstream 5-Gb/s 2^{31}-1 PRBS data which was *T/2* time-interleaved with respect to downstream data via a PM. After bidirectional transmission, the upstream signal was demodulated by a 10-GHz DI and was measured by a 12.5-Gb/s BER tester.

Fig.3 (a) shows eye diagrams of downstream and upstream signals before and after transmission in the proposed remodulation scheme when signal-to-crosstalk ration (SCR) was around 23 dB. The received signal at OLT was a 10-Gb/s DPSK signal interleaving upstream and downstream signals in *T/2* offset, with wide-open eyes at destructive port after a 10-GHz DI. By properly detuning the sampling point to the trailing half bits, 5-Gb/s upstream signal was successfully detected and the tested BER results are shown in Fig.3 (b). The receiver sensitivity of downstream and upstream signal at BER=10^{-9} are -23.6 dBm and -18.6 dBm, respectively. Downstream signal has negligible penalty (within 0.5 dB) and only around 0.8 dB penalty of upstream signal after bidirectional transmission is observed, implying robust tolerance toward Rayleigh backscattering.

To further investigate the effect of RBS noise in the proposed scheme, upstream signal using conventional non-zero on-off-keying (NRZ-OOK) remodulation scheme is also demonstrated in Fig.3 as a comparison. In Fig.3 (a), it can be observed that marks of the received

	Time-interleaved DPSK	NRZ-OOK
Back-to-back		
20km SMF+DCM		

(a)



(b)

Fig.3. (a) Eye diagrams and (b) BER measurement results of upstream time-interleaved phase remodulated signal and NRZ-OOK remodulated signals.

NRZ-OOK upstream signal at OLT suffer from severe distortion due to RBS which also leads to an error floor in BER curve as shown in Fig.3(b), while slight distortion in the eye diagram as well as a small value of power penalty after transmission using the proposed remodulation scheme.

4. Conclusion

We have proposed and experimentally demonstrated a time-interleaved phase remodulation scheme in WDM-PON which achieves error-free transmission of both downstream and upstream data with enhanced RBS tolerance.

5. References

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