A Novel Scheme to Integrate All-optical Burst Amplification and Cloning/multicasting in OBS Node

X.Y. Cao, X.B. Hong, H.X. Guo, Y. Li, Y. Zuo, K. Xu, J. Wu, J.T. Lin

Key Laboratory of Information Photonics and Optical Communications
Beijing University of Posts and Telecommunications, Beijing, P.R.China
xiaoyuan528@gmail.com

Abstract *A novel scheme that integrates suppression of transients for burst amplification and generation of cloned bursts all-optically is proposed and demonstrated experimentally. Impacts of control power and burst parameters are investigated while results are optimized.*

Introduction

Optical burst switching (OBS) has been proposed as one of the promising technologies for the next generation all-optical networks. Burst amplification and multicasting in optical domain are two key issues in OBS node. For burst amplification, special techniques should be adopted to suppress the transient response in EDFAs because of their inherent gain dynamics, including using the feedback control[1] and the gain-clamping technique[2]. On the other hand, burst cloning can be used to achieve burst multicasting to meet the increasing demands for applications such as real-time video conferencing and online multiuser games, as well as a proactive scheme to reduce burst loss in OBS networks[3]. Although currently, optical multicasting can be realized with multicasting OXC[4], which basically uses the splitter-and-deliver structure, there're no specially designed schemes for burst cloning/multicasting.

A novel scheme that integrates both of the above functions is proposed in this paper for the first time. With the complementary bursts generated in SOA due to XGM effect, EDFA transients are suppressed and in the meantime burst cloning is achieved for multicasting. Experimental results show that the power variation of the amplified bursts is less than 1 dB and bursts are excellently cloned with high signal-to-noise ratio (SNR).

Scheme and principle

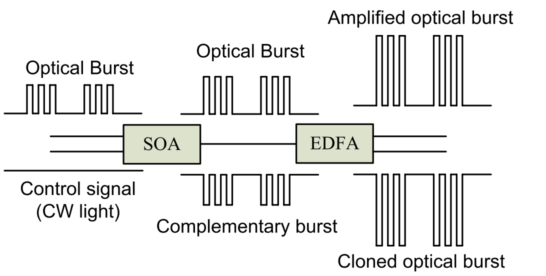


Fig.1 Scheme for burst amplification and cloning

Fig. 1 explains the scheme in OBS node that integrates both burst amplification and cloning. The original optical burst and a CW light at different wavelength are fed into a SOA simultaneously. As a result of the XGM effect in SOA between the bursts and the control signal, the gain experienced by the control light is reduced when the burst signal is high and, conversely, increased when it's low. Because of the fast response of gain in SOA, the CW control light is converted into a complementary burst of the input burst, which can be used as the cloned burst as well as a compensation of the power variations of the original burst. Then the original burst and its cloning (complementary) burst are launched into EDFA together with almost constant power to suppress the transients of EDFA. After a wavelength demultiplexer, both the amplified burst without waveform distortion and the cloned burst originated from the CW control light are obtained.

Experimental results and discussion

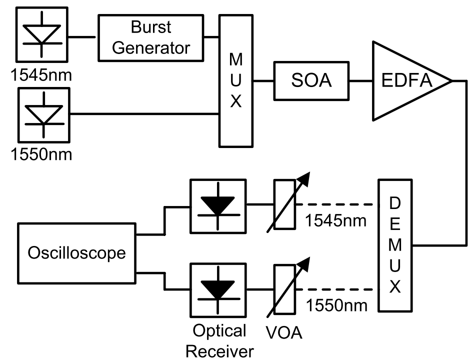
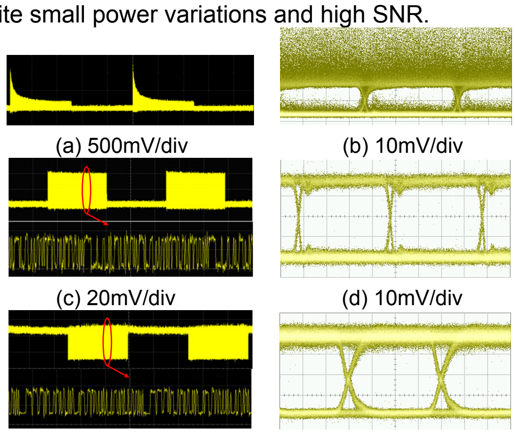


Fig.2 Experimental setup

The experimental setup of the proposed scheme is shown in Fig. 2. A CW light at wavelength 1544.94 nm was launched into a burst generator to generate a 250-μs-long periodic burst signal with a duty cycle of 0.5 and a 2.5 Gb/s 2^7-1 pseudorandom binary sequence was applied. Another CW light at wavelength 1550.10 nm was used as the control signal. The burst signal and the control signal were combined with a wavelength multiplexer. The average power of the burst and the control light before the SOA were 0.85 dBm and -3.60 dBm, respectively. The combined signals were fed into a commercial SOA (CIP SOA-NL-OEC-1550) and the bias current of the SOA was set to 150 mA, under which condition the input burst signal was strong enough to saturate the gain of the SOA. The EDFA was placed after the SOA and the gain of the EDFA was about 16.7 dB. After amplification, the signals were split by a wavelength demultiplexer and monitored with an oscilloscope after being detected by an optical receiver.

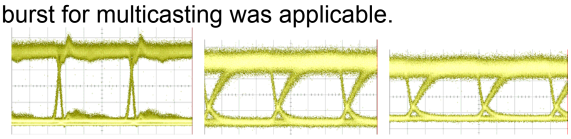
Fig. 3(a) and (b) show the waveform of amplified bursts and the corresponding eye diagram without transient control, i.e. launching only the input bursts directly into EDFA. Large amplitude variations (≈12 dB) and serious burst distortion can be seen from the results. In contrast, Fig. 3(c) and (d) show the amplified bursts with transient control, which manifest small amplitude variations (<1 dB) and high SNR. Fig. 3(e) and (f) show the cloned bursts which also has quite small power variations and high SNR.



(a) 500mV/div (b) 10mV/div (c) 20mV/div (d) 10mV/div (e) 20mV/div (f) 10mV/div

Fig.3 Waveforms and eye diagrams with one control signal

Fig. 4 exhibits the eye diagrams of amplified burst (a) and two cloned bursts (b, c) when two control signals (-5.6 dBm at 1550.29 nm, -5.8 dBm at 1534.44 nm) are used to perform burst cloning, proving that cloning multiple copies of the original burst for multicasting was applicable.



(a) 10mV/div (b) 10mV/div (c) 10mV/div

Fig.4 Eye diagrams with two control signals

Fig.5 illustrates the impact of the control signal on the Q-factors of the received signals. High Q-factors (>6) which mean low bit error rate are achieved for both the original burst (OB) and the cloned burst (CB). For the OB, the weak control signal (-6.59 dBm) can't generate strong enough complementary bursts to compensate the power variations of the signals into EDFA and thus EDFA transients remain significant, while the strong control signal (-0.72 dBm) consumes most of the gain, which causes the insufficient amplification of OB. Therefore an optimized injection power (-3.60 dBm) of the control signal is applied to get about 0.8 dB and 0.4 dB improvement in Q-factors respectively, compared with the cases of weak control light and strong control light. However, for the CB, low power (-8.62 dBm) of the control signal makes the XGM effect in SOA more efficient and consequently causes the higher Q-factor of generated CB, which means that there is a tradeoff as determining the optimal power of the control signal.

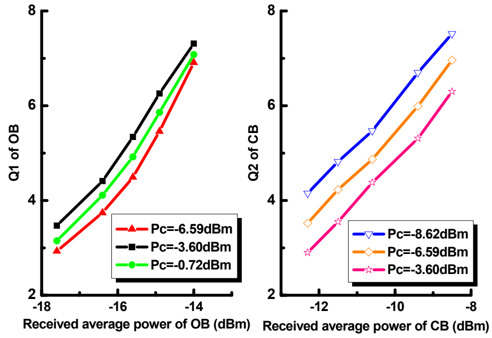


Fig.5 Q for different powers of input control signal (Pc)

The difference in amplitude variations between received OB with or without transient control is defined as transient suppression value (TSV). Fig.6 shows the impacts of burst length (BL) and duty cycle (DC) on TSV. Longer bursts have to endure more EDFA transients and similarly, longer inter-burst gap causes greater gain overshoot. As the variations of amplified bursts with transient control are uniformly within 1 dB, the TSV increases from below 6 dB to above 12 dB when bust length increases from 62.5 us to 500 us and duty cycle decreases from 0.9 to 0.1.

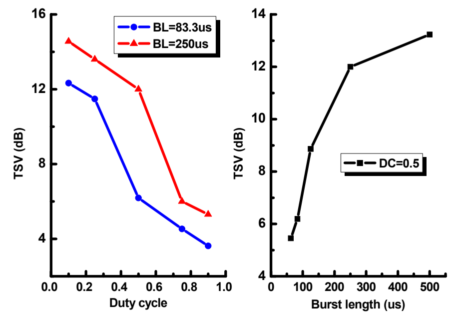


Fig. 6 TSV versus duty cycle & burst length

Conclusions

A novel scheme for all-optical burst amplification and cloning/multicasting in OBS node is proposed, which is easy to construct and implement. EDFA transients are suppressed significantly and multiple burst copies with high Q-factors are cloned for multicasting. The optimized control power is found to suppress EDFA transients to minimum and also to produce better cloned burst. In addition, with burst length and duty cycle changing, power variations of received bursts can always be suppressed to within 1 dB.

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