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Multi-level Burst Power Transient Suppression using Semiconductor Optical Amplifiers in Gigabit Access Links

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Abstract

For 10 Gb/s transmission limited by multi-level burst transients to non error-free performance, including an SOA reduces the penalty to 0.4 dB relative to back-to-back transmission.

Introduction

Gigabit optical access links are commonly implemented by using passive optical network (PON) architectures. In order to reduce the cost of the overall system, a proposed approach is to extend the reach and the power budget of conventional GPON systems from 20 km to over 60 km and the splitting ratio to beyond 128. Therefore, optical amplification either in the form of EDFA, Raman amplification or semiconductor optical amplifiers (SOA) has been considered in extended reach PON links [1,2,3]. The received signals in such systems may exhibit large power level differences and will therefore require special attention to assure proper detection and system operation. For example, bursts arriving from the optical network units (ONUs) to the central office (CO) may have non-uniform values up to 13 dB, for the case of a GPON system due to differences in path loss, power splitter non-uniform loss and non-uniform launch power levels [4]. Another scenario which gives rise to power transients is gain transients that may arise in EDFAs and Raman amplification solutions due to the bursty nature of the traffic aggregated from the ONUs. Under such conditions the intensity of the individual bursts will vary, giving rise to a multi-level power transient. Numerous methods for dealing with power transients including the use of SOAs [4,5], and various forms of amplifier gain clamping methods [6] have been proposed. In this paper we demonstrate how an SOA operating close to the saturation region of the gain curve reduces the receiver sensitivity penalty associated with multi-level burst power transients in 10 Gb/s transmission.

Experimental setup

The experimental setup is shown in Figure 1. Multi-level power transients with a burst period of 25 ms were generated by a signal wave generator. This electrical signal was used to drive a directly modulatable (DM) laser at 1554.2 nm biased above its lasing threshold. This emulates the multi-level power burst signal arrival scenario. The average power fluctuation of the multi-level transients was around 3.1 dBm. High speed intensity modulation was imposed onto the lightwave signal using a Mach-Zehnder intensity modulator (MZM) driven by a 10 Gb/s NRZ signal. The lightwave then entered a reflective semiconductor optical amplifier (RSOA) operating in the near-saturated region of the gain curve in order to equalize the power levels of the burst transients. A 1554.1 nm holding beam was used to improve the SOA performance by inducing a higher stimulated recombination rate, shortening the carrier lifetime, and reducing patterning effects [7]. The average optical powers of the data signal and holding beam into the SOA were -11.2 dBm and -0.7 dBm respectively. Two polarization controllers (PC) were used to optimize the input state of polarization of the signal and holding beam into the SOA since the device was polarization sensitive. A 0.39 nm FWHM filter positioned after the SOA was used to filter out the holding beam and the ASE noise, after which the signal was detected and the BER was measured using a 2^{31}-1 PRBS pattern length.

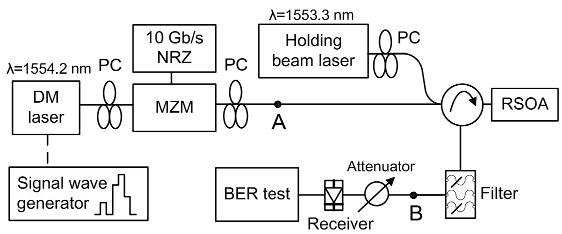

Figure 1: Experimental setup

Experimental results

Figure 2 shows the BER measurement results illustrating the effectiveness of the SOA in restoring the system penalty arising from the multi-level burst power transients. Also presented in the inset of Figure 2 are the transient waveforms, which were

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captured using a low speed photodiode. Figure 3 shows the optical and electrical eye diagrams associated with the multi-level burst power transients, both with and without the inclusion of the SOA in the experimental setup. The optical eye diagrams were measured using a broadband optical head of an oscilloscope, while the electrical eye diagrams represent the electrical signal from the receiver used for the BER measurements.

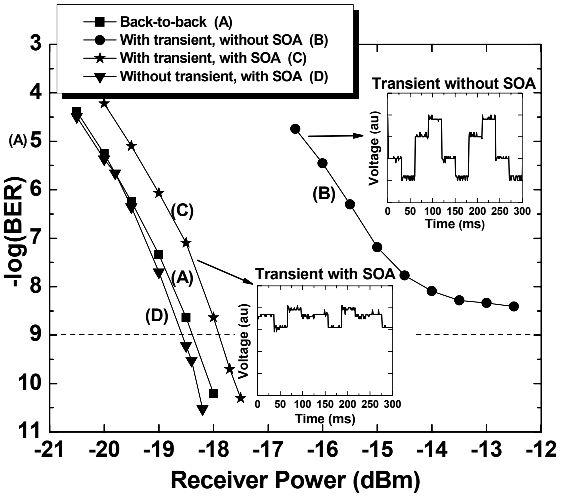

Figure 2: BER measurement results and multi-power level burst transient waveforms

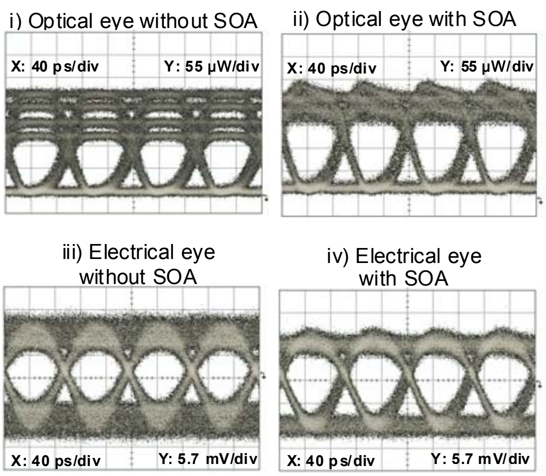

Figure 3: Optical and electrical eye diagrams, with and without the SOA in the experimental setup

For the back-to-back BER measurement without the SOA and without the transient (curve A in Figure 2), the receiver sensitivity at a BER of 10^{-9} was found to be -18.4 dBm. When the three-level burst transient was activated without the SOA (i.e. with points A and B in Figure 1 connected by a patchcord) a power penalty of around 4 dB was introduced for receiver powers below -14.5 dBm, while a BER floor of around 3×10^{-9} is reached for receiver powers above -14.5 dBm (curve B in Figure 2). The periodical three level transient power burst is seen to manifest itself as a three level distortive closure of the optical eye in Figure 3 (i). The difference between the power levels of transient bursts can be computed from the analysis of such eye diagrams. The distortion in the electrical eye diagram after the signal is detected by the receiver is also clearly evident in Figure 3(iii).

With the inclusion of the SOA in the experimental setup as shown in Figure 1, the system performance is restored and the multi-level burst transient penalty at a BER of 10^{-9} is reduced to only 0.5 dB relative to the back-to-back case (see curve C in Figure 2). The effectiveness of the SOA in restoring the system performance is also evident in the re-opening of the associated optical and electrical eye diagrams of Figure 3 (ii) and (iv). From the transient waveform corresponding to curve C in Figure 2, the SOA is seen to partially equalize the transient burst power levels, as expected by the device operating near the saturation region of the gain curve. It was found that the transient burst power levels could be equalized to different degrees by adjusting the optical signal input power into the SOA and operating at different points on the SOA gain curve. Operating deeply within the saturated region of the SOA gain curve was found to almost completely equalize the transient burst power levels, however, this adversely affects the system performance by erasing the intensity modulated data from the signal lightwave.

Conclusions

An SOA was shown to successfully equalize multi-level burst power transients of the type occurring in gigabit access links. For 10 Gb/s transmission limited by transients to non error-free performance, the introduction of an SOA was shown to reduce the transient penalty to 0.4 dB at a BER of 10^{-9}.

References

1. Nesset et al., ECOC 2006, Tu1.3.1.
2. Monroy et al., OFT, 14(1) (2008), pp. 41-44.
3. Nesset et al., ECOC 2006, Mo.4.5.1.
4. Appathurai et al., OFC 2007, OWS2.
5. Hallax et al., World Intellectual Property Organization, Patent No. WO 98/19416 (1998).
6. Karasek et al., JLT, 18(3) (2000), pp. 308-313.
7. Yu et al., JLT, 19(5) (2001), pp. 614-623.