Enhanced Optical Budget System Performance of an Burst Extended PON at 10.7Gbit/s over 60km of Fibre

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Abstract

A 10.7Gbit/s upstream extended PON was demonstrated over 60km of fibre in burst configuration. A budget of 39.5 and 55dB was achieved without and with SOA respectively.

Introduction

Recent Fibre To The Home (FTTH) launch in both North America and Europe was driven by the exponential need of high bandwidth of customer services as high definition television, digital photography and video, high-quality on-line video gaming, fast peer-to-peer file transfer, etc. The GPON (Passive Optical Network) concept was chosen by France Telecom Group since GPON aims at being the best candidate to provide an economical implementation of access fibre networks capable of carrying broadband services. Even the PON is still in its early stages of deployment, it must be upgradeable.

In this paper, an extended TDM Next Generation Passive Optical Network (NGPON) architecture operating at 10.7Gbit/s, bit rate usually used with the Forward Error Correction (FEC), is presented. Burst mode configuration for the upstream transmission working at 1310nm was tested. The experiments were focused on the upstream TDMA transmission in a 60km link. A maximum optical budget of 39.5 and 55dB was achieved without and with Semiconductor Optical Amplifier (SOA) respectively. Furthermore, we obtained a wide dynamic range of 15dB.

PON architecture without amplification

The experimental set up for the TDM/TDMA-PON configuration is shown on figure 1. The ONUs contain Direct Modulated DFB lasers (DML) from Emcore-Ortel. Their central wavelengths are around 1310nm with mean output power of +12.5dBm and their cut-off frequency, at -3dB, is 14GHz. The modulation voltage, in burst mode, is applied to the modulator section while the DFB laser bias current is controlled by a burst mode driver to coerce the operating current in burst configuration.

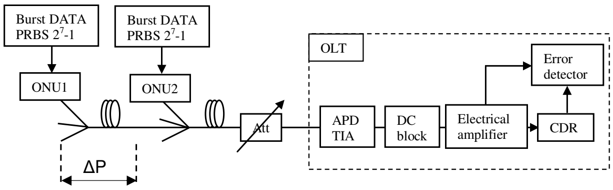

Figure 1: Schematic of the TDM(A)-PON network at 10.7Gbit/s in burst mode configuration with a continuous block receiver

At the OLT, the receiver stage of the burst upstream signal consisted of an APD-TIA photodiode. Its sensitivity is around -27dBm and its input overload is around -4dBm. We introduced a DC Block behind the photodiode to be in an AC coupled input interface. Note that no Automatic Gain Control (AGC) is implemented. Moreover, a broadband electrical amplifier follows the DC Block and a Phase-Locked Loop Clock Recovery (PLL-CR) module was introduced in the block receiver

Extended PON architecture with SOA

Extended reach GPON are more and more studied to ensure alignment with current standards by increasing the optical budget and by demonstrating an extended system working at 1310nm [1]. In our study, we focus on the extended reach PON of the upstream traffic working at 10.7Gbit/s.

Figure 2 shows the extended PON architecture. It is the same architecture in the figure 1 but with the implementation of in-line amplification. The SOA used in this study is a commercial device with a peak wavelength at 1310nm and 60nm bandwidth. It has a gain of 20dB and a Noise Factor (NF) closed to 5dB. It should be noted that no optical filter was introduced in front of the photodiode so that the SOA Amplified Spontaneous Emission (ASE) noise was not filtered.

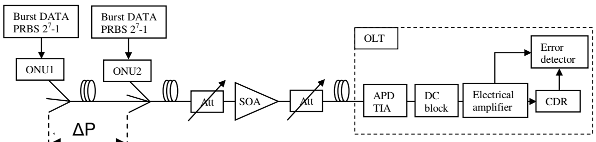

Figure 2: The Extended -PON network at 10.7Gbit/s in burst mode configuration with a SOA

Experimental results

In this part, the characterization of the transmission of the burst optical traffic is presented. To generate this traffic, the two DFB lasers in the ONUs were modulated in burst mode at 10.7Gbit/s with an extinction ratio of 8dB. The packet consisted of non-return to zero (NRZ) pseudo random binary sequences (PRBS 2^7 = 128 bits). The total packet time was around 4µs. The guard time (Tg) and the ONU on- and off-time were taken into account in the header. No preamble was applied. A significant difference of power, ΔP=15dB, between the nearest

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and the furthest ONU to the OLT was implemented. Figure 3 illustrates the burst mode traffics.

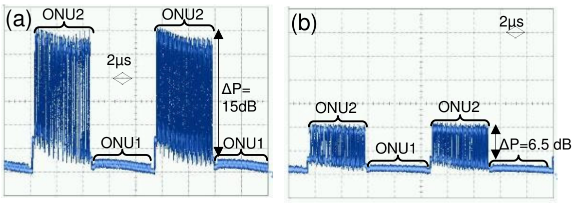

Figure3: Optical signals, (a) before the online SOA, (b) after the SOA

Results of the PON architecture without SOA

The Bit Error Eate (BER) results were evaluated for the burst transmission at 10.7Gbit/s as shown in figure 4. The BER values were recorded in terms of the received power only during the burst time. High sensitivity of -27dBm was obtained at a BER of 10^{-9}. The APD input overload is over -4dBm. About 9dB improvement is realized compared to the last studies [2]. To our knowledge, it is the first PON having at least an optical budget of 39.5 dB @ 10^{-9} (with DFB-DML power +12.5dBm) and operating at 10.7Gbit/s [3-4]. Furthermore, a dynamic range ΔP of 15dB was tested over 0km, 20km and 40km link fibre. With 60km fibre, only ΔP=7dB was tested. Moreover, 23.4dB optical loss over 60km fibre had been obtained due to higher fibre losses at 1310nm. Also, losses of 9.5dB are assumed for the 1x4 splitter and insertion loss of the variable optical attenuator (VOA) used to measure the optical budget. A dynamic range ΔP of 20dB was obtained over a maximum of 20km fibre. The burst mode over fibre penalties are very small, and are less than 0.5dB according to the curves on figure 4.

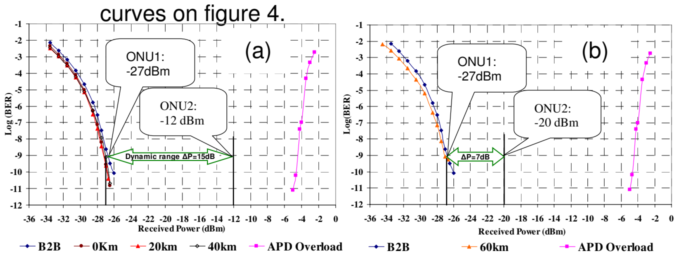

Figure4: Upstream BER performance vs. the received power for (a) ΔP=15dB and (b) ΔP=7dB

Results of the PON architecture with SOA

In this part, we evaluated the budget performance of the amplified PON architecture. The aim is to determine an optimal working area. This area presents the best combination of an access optical budget (measured between the ONUs and the SOA) with 15dB dynamic range and the extended optical budget (between the SOA and the OLT). These working areas, shown on the figure 5, were obtained by fixing a value of the access budget (16 to 40dB) and varying the extended budget (10 to 44dB). We delimited the areas according to the measured bit error rate values. A maximum optical budget of around 55dB was measured in the optimal working area. About 12.2dB improvement is realized compared to the last studies [5]. In this area, the access optical budget is included between 18 and 33dB and the extended one is between 18 and 23dB.

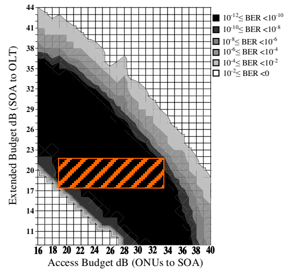

Figure5: Extended budget area vs. the Access Budget

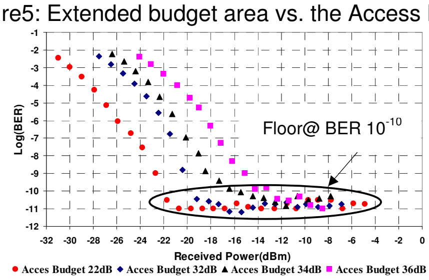

Figure6: BER curves vs. the received power

Figure 6 shows the transmission performance through four BER curves. Each curve shows the BER as a function of received power for a fixed access budget while the extended one was varied. A floor appears at a BER of 10^{-9}.This is due to the ASE noise. Indeed, the absence of optical filter before the block receiver in the OLT side induces beat noise between signal and ASE at the photodiode

Conclusion

An upstream extended PON at 10.7Gbit/s was evaluated. The two ONUs included DML-DFB with +12.5dBm output power and the OLT contained an APD-TIA in AC coupled configuration and a PLL-CR. This is the first report of burst mode PON including SOA at 10.7Gbit/s. In addition, we obtained a high sensitivity (-27dBm) and a widest dynamic range (20dB up to 20km, 15dB up to 40km and 7dB up to 60km fibre link). A total budget of 39.5 and 55dB was achieved without and with SOA respectively.

Acknowledgments

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References

[1] R. Davey et al, OFC2008, OThL1
[2] S. Nishihara et al, OFC2007, PDP8
[3] Z. Belfqih et al, OFC2008, PS JWA 112
[4] J. Nakagawa et al, OFC2007, OWS3
[5] K.I. Suzuki et al, OFC2008, OThL3