3.5 Gb/s Burst-Mode Clock Phase Aligner for Gigabit Passive Optical Networks

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— We demonstrate a 3.5 Gb/s burst-mode receiver featuring instantaneous (0-bit) phase acquisition for any phase (±2π) between packets in GPON. Our design is based on a 2× oversampling local oscillator and a phase picking algorithm.

I. Introduction

Passive optical networks (PONs) are an emerging multi-access network technology that provides a low-cost method of deploying fiber-to-the-home. Fig. 1 shows an example of a PON. In the upstream direction, the network is point-to-multipoint: using time-division multiple access (TDMA), multiple optical network units (ONUs) transmit bursty data to the optical line terminal (OLT). Due to optical path differences, packets can vary in phase and amplitude when received by the OLT. To deal with these variations, the OLT requires a burstmode receiver (BMRx). The BMRx front-end comma bits.

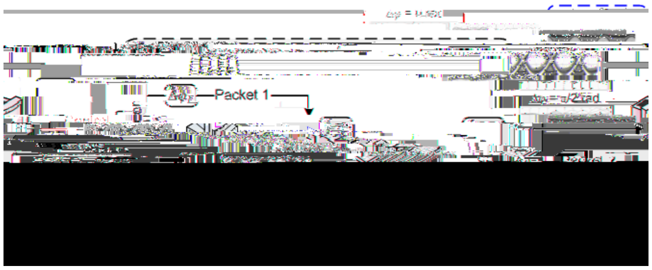

Fig. 3: Experimental setup (LPF: low-pass filter).

Fig. 4 shows the PLR performance of the system as a function of the phase difference between consecutive packets. Fig. 4(a) depicts the phase step response of the receiver with only the CDR and the CPA turned off (mode 1), for different preamble lengths at 1.25 Gb/s. The reason why we have a bell-shaped curve centered at 400 ps is that this is the half bit period corresponding to the worst-case phase step (´ rads), and therefore the CDR is sampling exactly at the edge of the eye diagram. Preamble bits ("1010..." pattern) can be inserted at the beginning of the packets to help the CDR settle down and acquire lock. However, the use of the preamble reduces effective throughput and increases delay. As the preamble length is increased, there is an improvement in the PLR. We observe error-free operation (PLR < 10^{-6}) for any phase step after 28 preamble bits. This does not satisfy the 28-bit requirement for both, phase and amplitude recovery, specified in the G.984.2 standard [2].

However, by switching on the burst-mode functionality of the receiver with the CPA (mode 2) as shown in Fig. 4 (b), we observe error-free operation for any phase step (0 Ò $\Delta\varphi$ Ò 2´ rads) with *no* preamble bits, allowing for instantaneous phase acquisition ī well below the 28-bit specification. We also plot the phase step response of the receiver at 2.5 Gb/s[1]. Again, as expected, with only the CDR, the curve is centered at 200 ps as this is the half bit period corresponding to the worst-case phase step (´ rads) at 2.5 Gb/s.

By replacing the PLL based CDR by the LO (mode 3), we also obtain error-free operation for any phase step with no preamble bits for data rates up to 3.5 Gb/s as demonstrated in Fig. 4(c). To the best of our knowledge, this is the first time that a BM-CPA is successfully implemented without CDR circuitry. This novel design is simpler and cheaper, without any reduction in performance.

IV. Conclusion

In conclusion, we successfully implemented a BM-CPA that operates up to 3.5 Gb/s and provides instantaneous phase acquisition. The price to pay is faster electronics. However, our CDR-free BM-CPA greatly reduces the complexity of electronics, providing a cost-effective solution for GPON receivers. We note that a sensitivity penalty results from the quick extraction of the decision threshold and clock phase from a short preamble at the start of each packet [3]. However, by reducing the phase acquisition time, as demonstrated in this work, more bits are left for amplitude recovery, thus reducing the burst-mode sensitivity penalty. Alternatively, with the reduced number of preamble bits, more bits can be used for the payload, thereby increasing the information rate.

[1] The CDR could not be tested for different preamble lengths at 3.5 Gb/s as this rate is not supported on commercially available SONET CDRs.

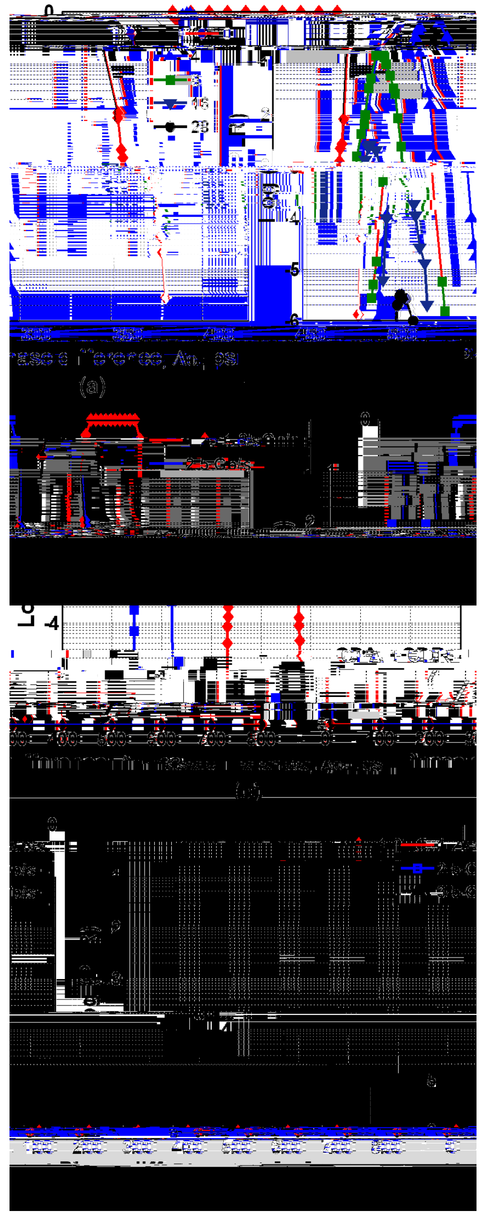

Fig. 4: PLR performance for the BM-CPA.

Acknowledgement

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References

[1] J. Faucher et al., in *Proc. IEEE LEOS Annual Meeting*, TuDD3, 2006

[2] *Gigabit-capable Passive Optical Networks: Physical Media Dependent layer specification*, ITU-T Recommendation G.984.2., 2003.

[3] P. Ossieur et al., *IEEE J. Lightw. Technol.*, vol. 21, no. 11, 2003.