2.5Gb/s GPON single-chip burst-mode receiver

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Abstract

This is the first 2.5Gb/s burst-mode receiver that satisfies GPON timing specification. The single-chip receiver IC archives -25.5dBm sensitivity, 21dB dynamic range, 18.5dB loud/soft ratio with p-i-n photodiode.

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Introduction

With recently soaring demand for high data rate services like IPTV, the passive optical network (PON) is considered as a cost-effective solution to provide Gb/s data rate to end-user. Figure 1 depicts typical architecture of a PON system, where in upstream the data packets from optical network units (ONUs) are multiplexed in time-division mode. The optical line terminal (OLT) needs a burst-mode receiver to recover signal packets with short guard time and large amplitude variation due to different optical path loss. The ITU-T standard GPON [4] is attractive due to its high bandwidth efficiency, which in return requires strict timing specification and makes it more difficult to design the burst-mode receiver. Therefore, even though burst-mode receiver for data rate up to 10Gb/s has been reported [2],[3], the receiver really satisfies GPON timing specification is for 1.25Gb/s [1] data rate only. In this paper, we present a single chip burst-mode receiver (BM-RX) for 2.5Gb/s GPON that exceeds the strict GPON timing specification. With high data rate, high sensitivity and wide dynamic range, the IC is a good solution for future 2.5Gb/s GPON upstream receiver.

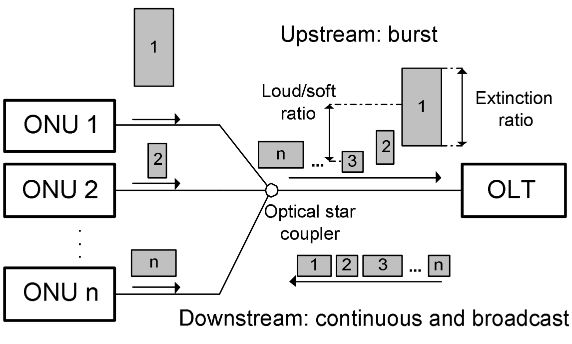

Figure 1: PON system architecture

GPON burst-mode receiver topology

The burst-mode receiver topology is shown in Fig. 2. The transimpedance amplifier (TIA) converts and amplifies current signal from the photodiode to single-ended voltage signal, which is converted to differential by single-to-differential converter (S2D) and further amplified by limiting amplifier with auto offset compensation (AOC) to a fixed amplitude. The output buffer (BUF) provides CML output matched to

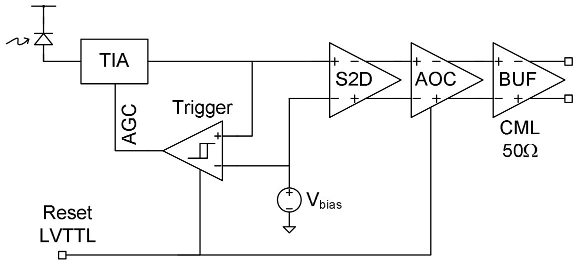

Figure 2: Burst-mode receiver IC block diagram

50Ω. An on-chip bias circuit generates bias voltage for the S2D. The trigger also uses this bias voltage as a reference to quickly switch the TIA to lower gain at the beginning of a burst by digitized AGC signal when input signal is strong, thereby extending dynamic range [1]. The trigger and the AOC are initialized by external reset signal during guard time before each burst to allow for fast response and high loud/soft ratio.

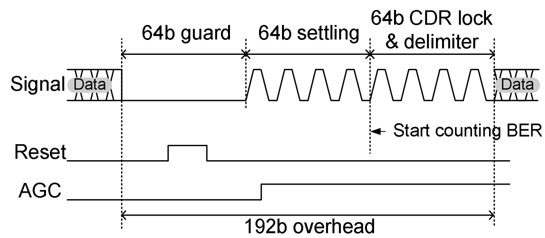

Figure 3: Anticipated 2.5Gb/s GPON upstream timing diagram

The timing specification of 2.5Gb/s GPON upstream in [4] is specified with minimum 64 bits guard time, suggested 20 bits delimiter and fixed 192 bits overhead. The 128 bits preamble time is filled with 1010 bit pattern. The state-of-the-art clock-data recovery (CDR) chip for 1.25Gb/s GPON available in the market needs 13 bits to lock, and there's no CDR chip for 2.5Gb/s GPON commercially available. Therefore we use a conservative estimate of 44 bits locking time for 2.5Gb/s GPON CDR, which results in 64 bits of settling time as our design target. The timing diagram is illustrated in Fig. 3.

TO-can burst-mode ROSA for 2.5Gb/s GPON

The BM-RX IC is optimized in chip size and compactness for assembly with photodiode in TO-can.

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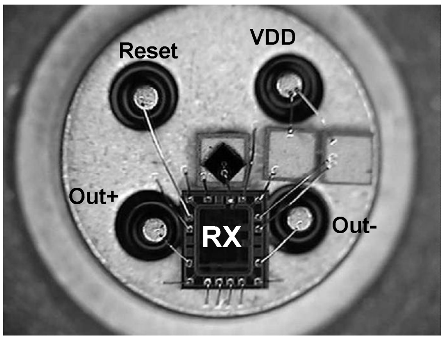

Figure 4: BM-RX IC in TO-can assembly with p-i-n PD

Pad arrangement is compatible with conventional continuous-mode TIA in the market, and current consumption of 37mA from 3.3V power supply is suitable for any compact OLT transceiver module design.

The sample assembly of the BM-RX IC with p-i-n PD in 5-pin TO-can is shown in Fig. 4. The receiver chip size is 1.05 x 1.2 mm^2. The chip is also suitable for 6-pin TO-can assembly if APD is needed to improve sensitivity.

Experimental result

A conventional p-i-n PD with 0.5pF parasitic capacitance and 0.9A/W responsivity is used for TO-can assembly with the BM-RX. The burst-mode environment is emulated by the Agilent ParBERT 82500. The loud/soft ratio is measured under worst-case condition in which burst data is the sequential alternative of a short, weak burst and a long, strong burst, with the requirement that BER of both weak and strong bursts are lower than GPON standard of 10^{-10}. In our measurement, BER counting starts after 64 bits settling time to guarantee accurate recovery of CDR lock and delimiter bits (Fig. 3).

As depicted in Fig. 5, the ROSA of BM-RX and p-i-n PD exhibits sensitivity of -25.5dBm and overload of -4.5dBm, resulting in 21dB dynamic range. Under worst-case burst-mode condition, the sensitivity reduces to -23dBm while overload stays the same, leading to 18.5dB loud/soft ratio.

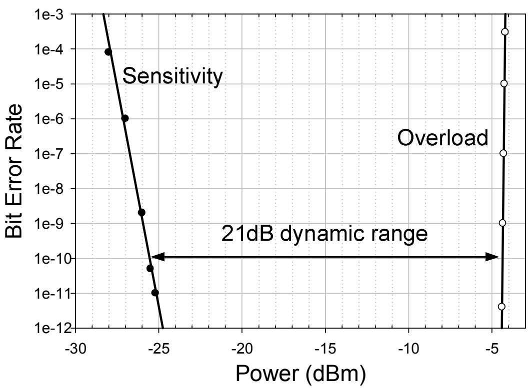

Figure 5: BER and dynamic range of BM-RX

	[1] GPON	[2] PON	[3] GE-PON	GPON standard	This work GPON
Data rate (Gb/s)	1.25	2.5	10.3	2.5	2.5
Sensitivity (dBm)	-30	-18	-19.5	n/a	-25.5
Overload (dBm)	-4	n/a	+1	n/a	-4.5
Loud Soft Ratio (dB)	26	n/a	14.7	n/a	18.5
Settling time (ns)	16	n/a	75	51.2*	25.6
Guard time (ns)	25.6	n/a	100	>25.6	25.6

* including CDR lock time and delimiter

Table 1 : Comparison of BM-RX

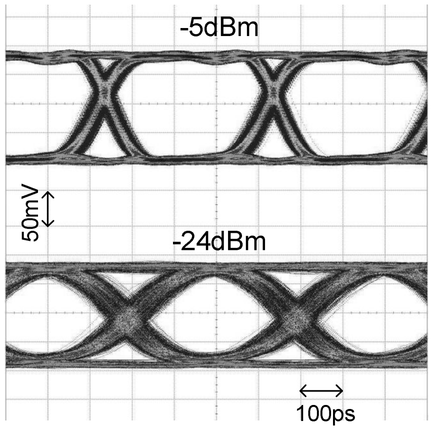

Figure 6: Typical eye diagram of BM-RX outputs

Typical eye diagram of BM-RX single output at -5dBm and -24dBm under burst-mode operation is shown in Fig. 6. A summary and comparison with previous works is given in Table 1. Due to the resolution limit of ParBERT system, lower settling time cannot be measured. However, based on output waveform, it is expected that the actual settling time is shorter than the measured value.

Conclusions

We report a BM-RX IC for 2.5Gb/s GPON with fast response, high sensitivity and high loud/soft ratio. To the best of authors' knowledge, this is the first reported BM-RX for 2.5Gb/s GPON that exceeds GPON timing specification.

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