10GEPON Burst Timing in Coexistence Situation

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Outline

1. Burst Timing in Worse Case of AC Coupling
2. Coexistence Problem
3. Differential AC Coupling
4. Conclusion

1. Burst Timing in Worse Case of AC Coupling

- Burst Timing is related to determination of

Laser on time	$T_{on;}$	
Lase off time	T_{off}	in ONU
Receiver setting time	$T_{rec.}$	
Clock/data recovry time	T_{cdr}	in OLT

- AC Coupling and DC Coupling have different influences on T_{on}, T_{off} , T_{rec}, T_{cdr} .

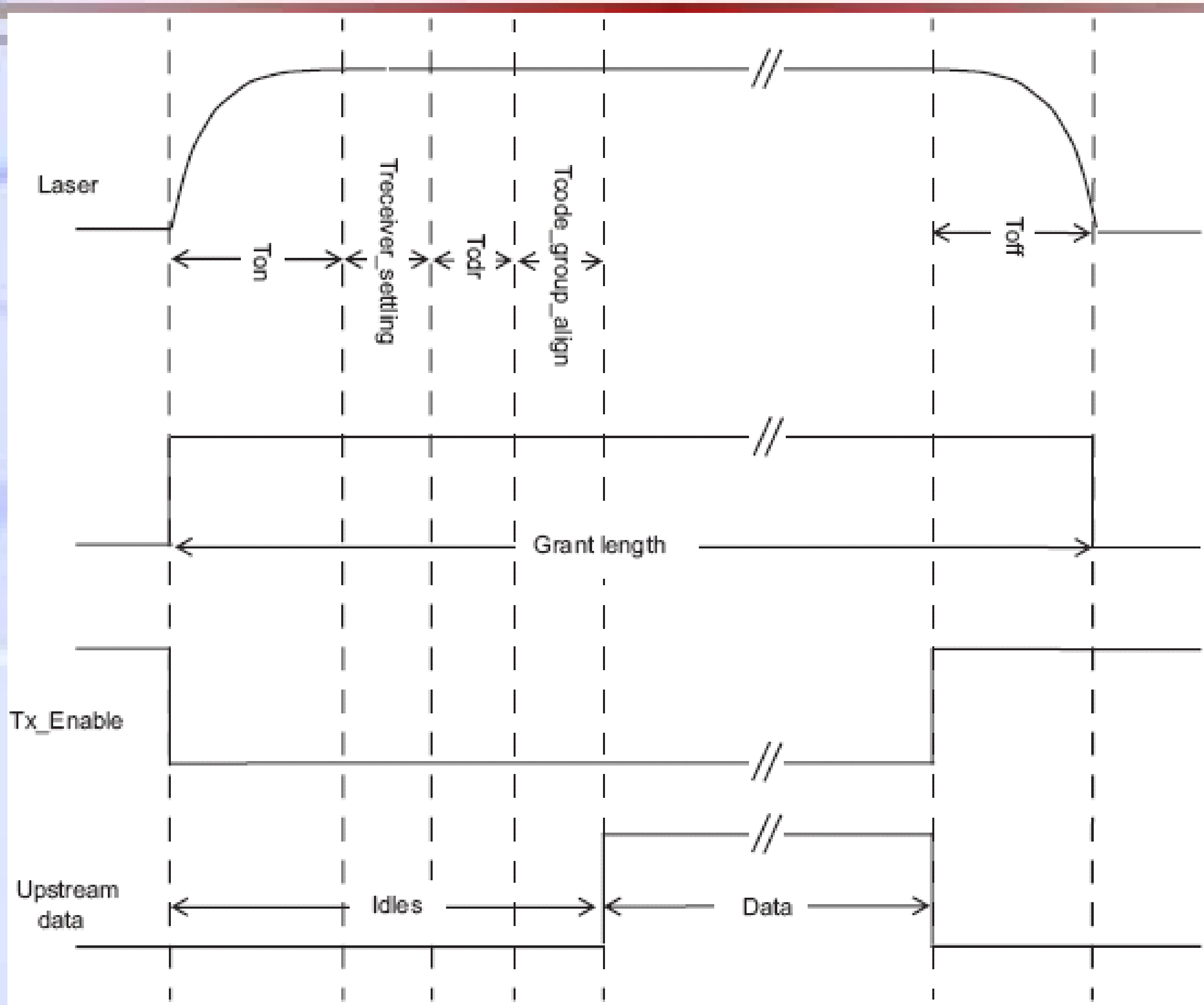


Figure 60–7—P2MP timing parameter definition

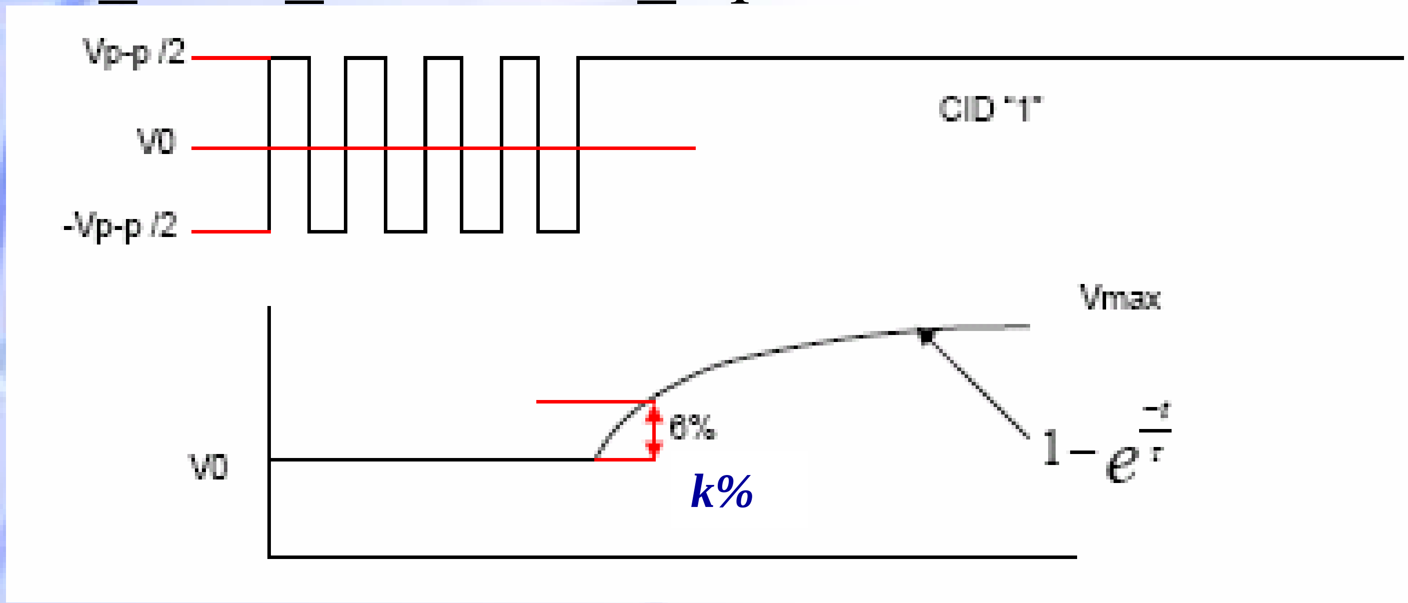
AC Coupling vs DC Coupling

- **Existing 1G PMD upstream solution are DC coupled. With DC coupling which makes little baseline DC drop, short Ton, Toff, T_{rec} and T_{cdr} and low Pattern Dependent Jitter can be reached.**
- **The DC-coupled single-ended interface between LD driver and LD caused the crosstalk from the uplink transmitter to downstream receiver in a 10 Gbps BOSA.**
- **High driving ability is required foe the LD driver in the DC-coupled interface and this requirement is difficult to satisfy with Si or SiGe process.**

- AC coupled interface from LD driver to LD and from TIA to CDR will allow semiconductor solutions using advanced CMOS technologies at lower power.
- But in AC Coupled applications with long CID the coupling capacitor generates baseline DC droop and Pattern Dependent Jitter. In order to minimize this jitter, the low frequency cut-off should be optimal.
- In other hand if the lower frequency cut-off is too low than the optimum level, it will cause jitter due to Flicker Noise.
- It is possible to achieve sub 100 ns lock time in burst mode CDR, but additional capacitors between TIA and CDR will add some low frequency jitter. It also requires additional settling time.

Baseline DC Wander in AC Coupling

- Refer to 《10GEPON Burst Receiver Simulation 》 3av_0801_benamram_2.pdf



$$\Delta V = \frac{k}{100} V_{p-p} = \frac{V_{p-p}}{2}(1 - e^{\frac{-t}{\tau}})$$

$$\tau = \frac{-N_{CID} T}{\ln(1 - \frac{k}{50})}$$

- **To keep DC wander low during the data package, time constant τ should be large enough.**

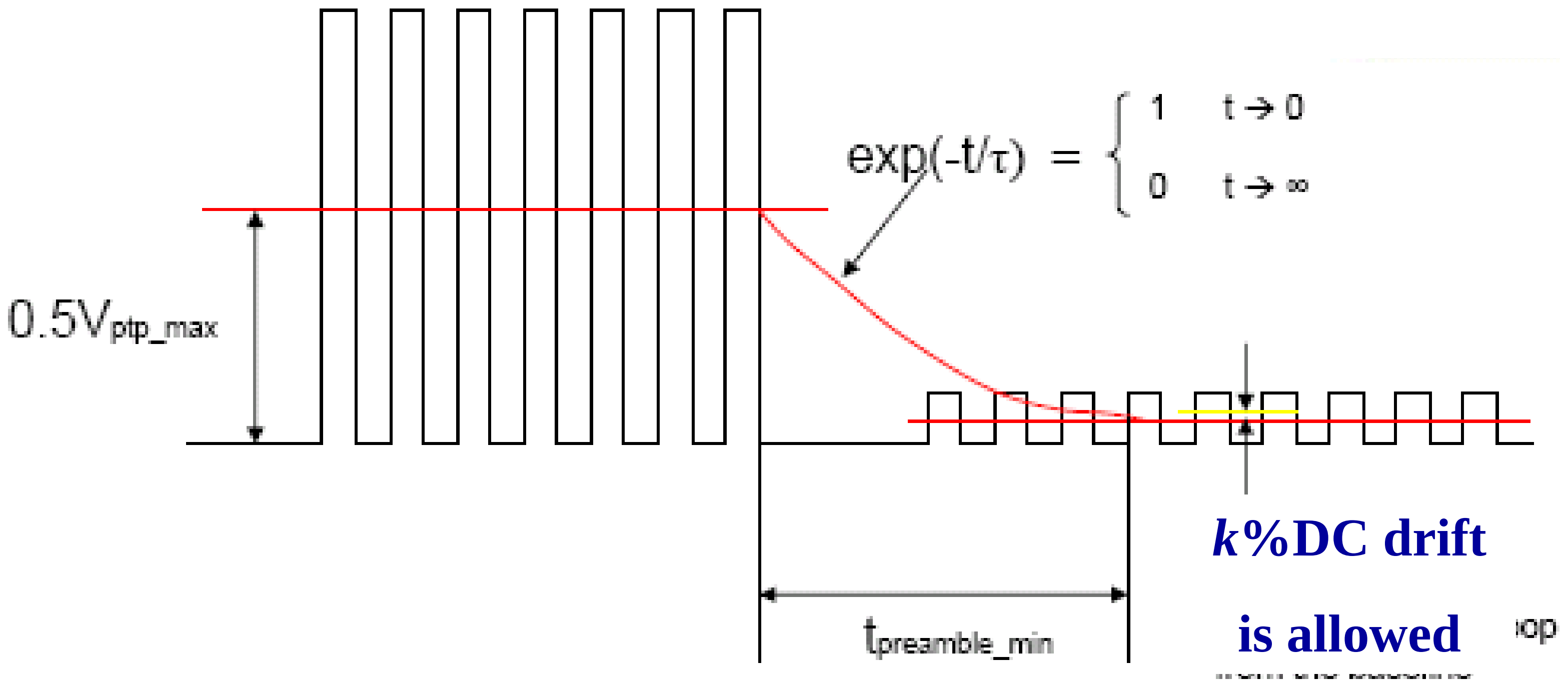
- Example of DC wander:

$\Delta V=5.5\%V_{p\text{-}p}$, $k=5.5$, $N_{CID}=64$, $T=1/f_b=0.097$ns

$$\tau=-\frac{N_{CID}T}{\ln(1-\frac{5.5}{50})}=8.58N_{CID}T=8.58\times64\times0.097\text{ ns}=53.27\text{ ns}$$

R=50 ohm, C=1065 pF

$$f_1=\frac{1}{2\pi\tau}=3\text{MHz}$$



- **From the strong burst to the weak burst DC component decays with time *t*. So time constant τ between the data packages should be small enough to make the receiver threshold settlement adaptively.**

- Example of Idle number Calculation

$$\frac{1}{2}V_{\text{p-pmax}}e^{-\frac{t}{\tau}} \le \frac{1}{2}V_{\text{p-pmin}}k\% \qquad t = -\tau \ln\left(\frac{V_{\text{p-pmin}}}{V_{\text{p-pmax}}} \times \frac{k}{100}\right)$$

Assume $V_{\text{p-pmax}}$ **=400 mV,** $V_{\text{p-pmin}}$ **=10 mV, *k*=5.5,**

$$t = N_{idle}T = 6.59\tau = 6.59 \times 8.58 N_{CID} T$$

$$N_{idle}T = 6.59 \times 8.58 \times 64T = 3618.3T = 360.7\text{ns}$$

- **This means that in AC Coupling case, considering the longest CID in data package, time constant is large, so the idle time between data packages approaches 400ns.**
- **Therefore, T_{rec}=400ns, T_{cdr}=400ns are proposed for Cause 91.**

2. Coexistence Problem

- Because 1G EPON and 10G EPON coexists in the future access networks, the dual bit rates problems should be solved.
- But in AC-coupled PMD, time constant τ is propotional to bit period T i.e. inversely propotional to bit rate 1Gbps and 10 Gbps.
- In hardware design one can build two parallel trancevers, each working at 1 Gbps or 10Gbps or build a commom transcever with coupling capacitance and TIA feedback resistance being switched over between 1 Gbps and 10 Gbps.
- The latter causes bit rate auto-sensing and switch control difficulties.

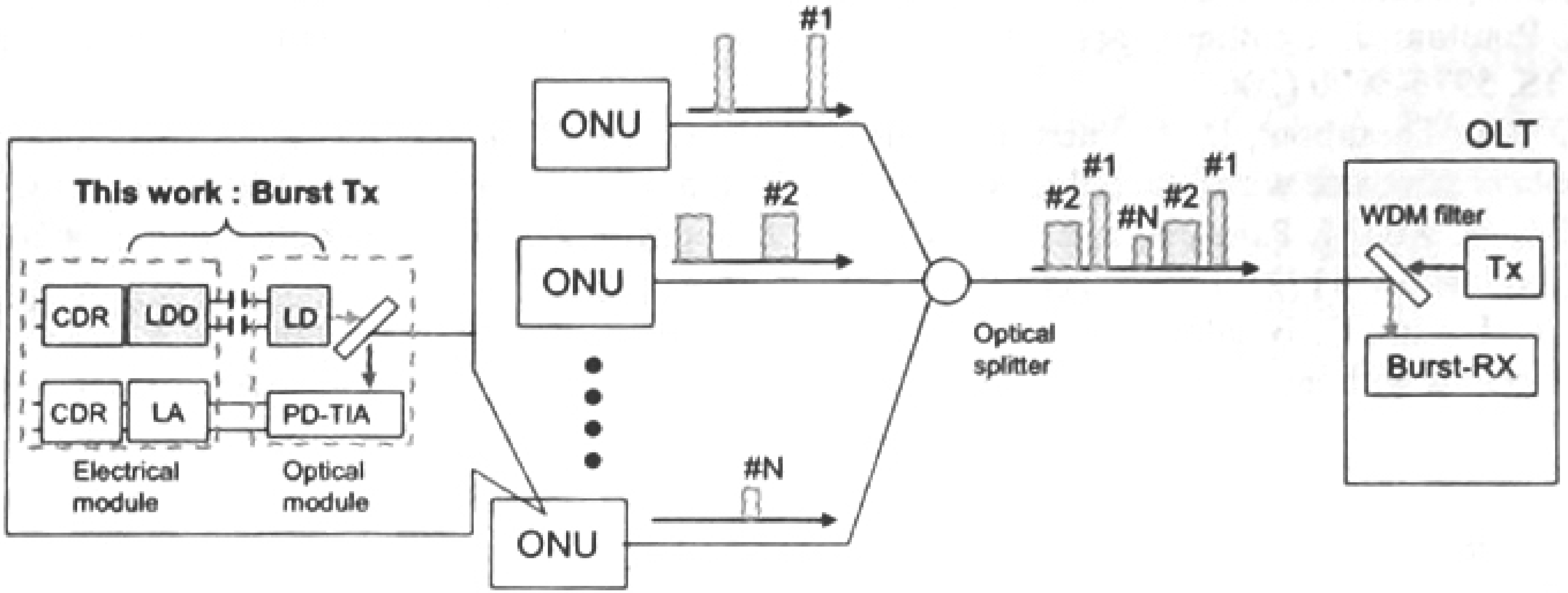
3. Differential AC Coupling

- **Can AC Coupling be made bit rate-independent?**
- **This presentation shows the advantages of Differential AC coupling**

  between LD driver and LD in ONU;

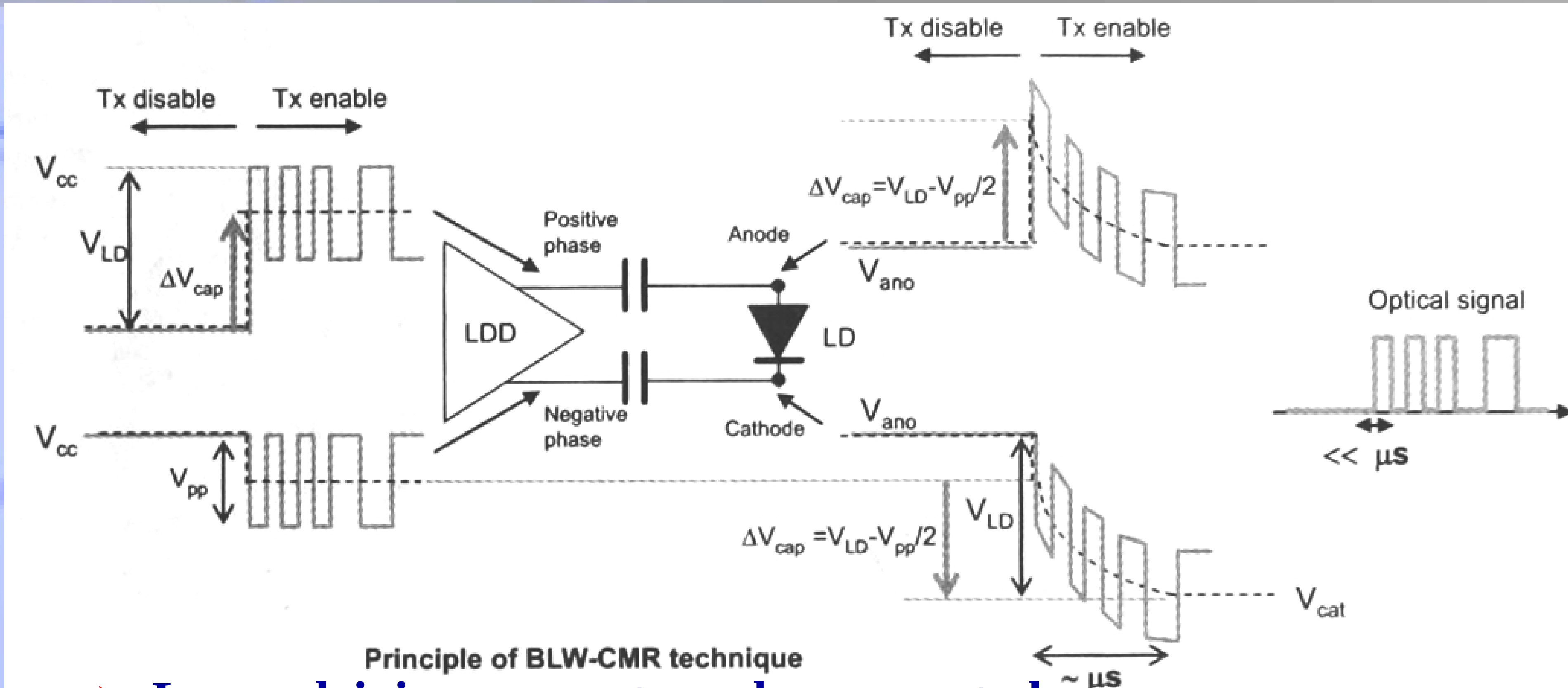
  between TIA and CDR in OLT.

Burst Tx in ONU



Burst-mode upstream signal in TDM-PON

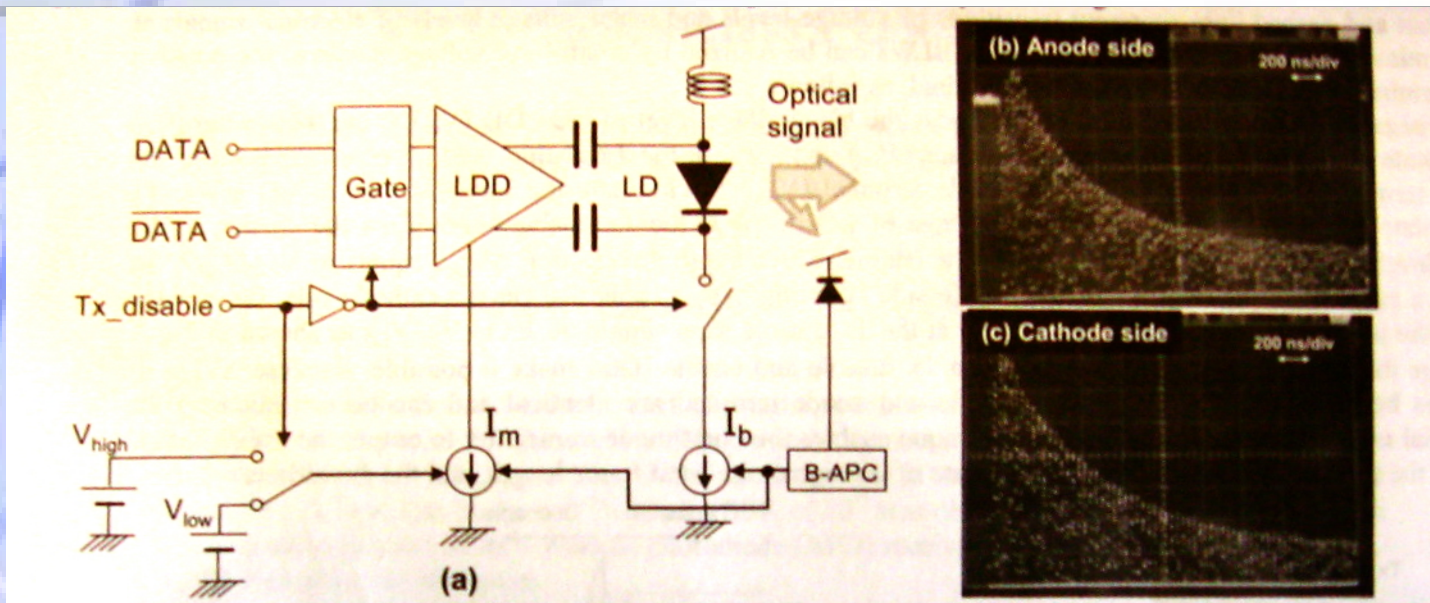
Differential AC Coupling in Burst Tx



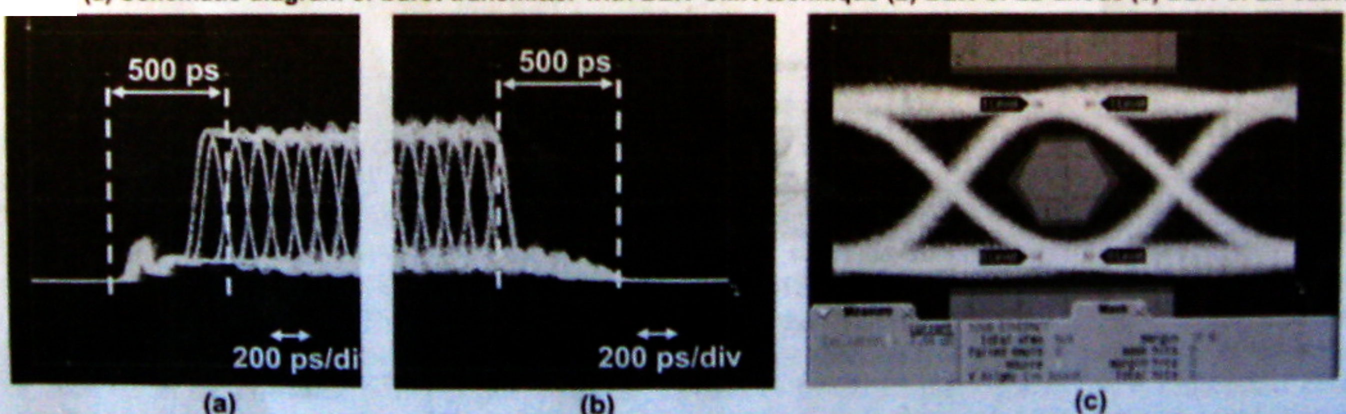
Principle of BLW-CMR technique

- Large driving current can be generated.
- Driving transient at the anode and cathode of laser is cancelled making the driving speed fast and independent of the time constant.

Experimental Results

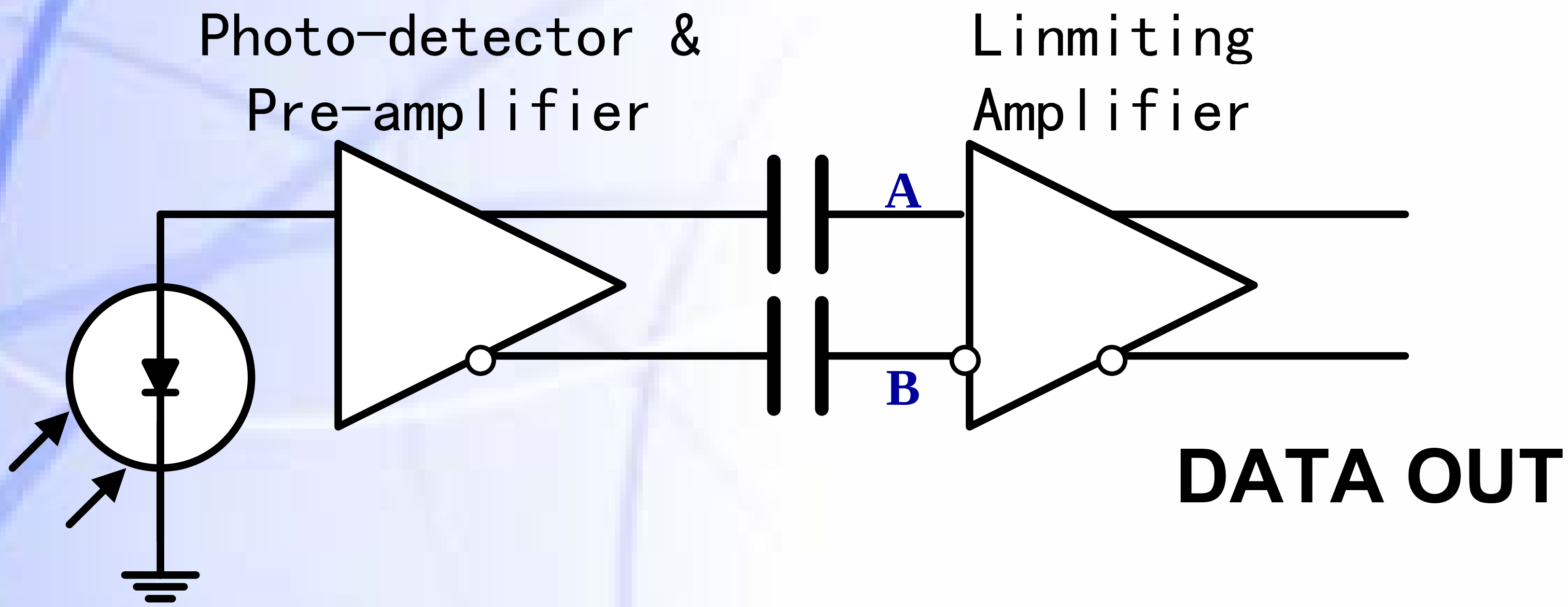


(a) Schematic diagram of burst transmitter with BLW-CMR technique (b) BLW of LD anode (c) BLW of LD cathode



(a) T_{on} (b) T_{off} (c) eye pattern of optical burst signal

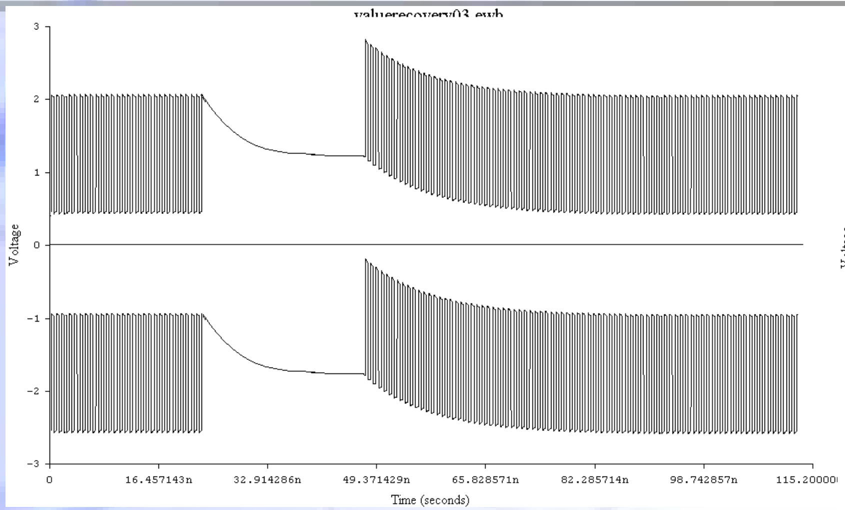
Differential AC Coupling in Burst Rx

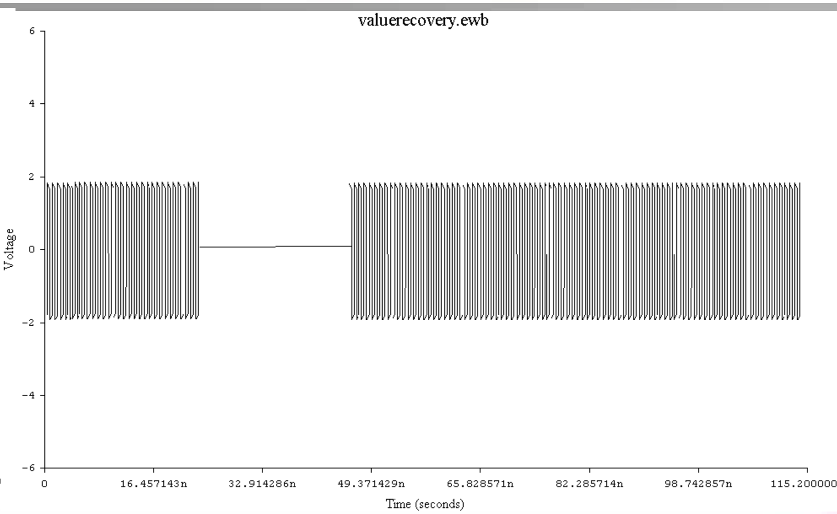


Input and Output of Limiting Amplifier

A input

B input





output

- Simulation shows that :
- Receiver output waveform is independent of coupling capacitance;
- There is no DC component in the receiver output, i.e. the decision threshold is zero. So the problem of decision threshold settlement problem in burst receiver is entirely elliminated!

4. Conclusion

- Burst timing in 1 Gbps and 10 Gbps EPON is related to the time constant of coupling circuits between LD Driver and LD in ONU and between TIA and CDR in OLT.
- Even though DC Coupling has faster responses which can make the burst timing parameters smaller. But from the viewpoint of feasibility of semi-conductor processes needed for burst Tx and Rx, AC Coupling may be a better choice.
- In conventional single ended RC coupling circuits, the speed of the transfer transient is related to the time constant which is inversely proportional to the data rate. The requirements on DC wander during a data package and decision threshold adaptation between two data bursts are usually contradictory.
- In the worst case of AC coupling, T_{on}=512ns, T_{off}=512ns, T_{rec} =400ns and T_{cdr}=400ns are suitable burst timing parameters for both GEPON and 10GEPON in Cause 91.

- **Dual rates coexistence needs to be dealt with. It is informative to indicate the possibility of designing bit rate-independent active circuits such as differential AC coupling, which is proposed to be included in Annex 91A.**

Referenses

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3. Hirotaka Nakamura, et al., 500-ps Response AC-coupled Burst-mode Transmitter using Baseline-Wander Common-Mode-Rejection Technique for 10-Gbits/s-class PON Systems, OFC/NFOEC'2008, PDP26.pdf.
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Thanks

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