Considerations for Tx Launch Power and Rx Sensitivity

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Introduction

- **There exists a general perception that Tx power and Rx sensitivity need to be far more conservative than is reasonable.**
- **This presentation is intended to facilitate discussion by considering Rx/Tx performance from mainstream Tx/Rx subcomponent manufacturers which are under development or in commercial deployment.**
- **The TF should take into account developments which are very likely to occur in PMD and PHY technology.**

A Review of Tx launch power

Piggyback on Tx with similar reach/budget capabilities:

- **1310nm SONET optics:**
  - 12km SR1 (ERmin 8.2dB, Pmin -4dBm)
  - 20 km IR1/S64.1 (ERmin 6dB, Pmin +1dBm)
  - 24 km IR1 (ERmin 8.2dB, Pmin -1dBm)
  - 40 km LR1/L64.1 (ERmin 6dB, Pmin +4dBm)
- **1310nm 10GbE optics:**
  - 10km LR/LW: (ERmin=3.5dB, Pavg=0.5dBm)
- **1550nm SONET optics:**
  - 25km SR2/I64.2 (ERmin=8.2dB, Pavg=-1dBm)
  - 40km IR2/S64.2 (ERmin=8.2dB, Pavg=0dBm)
  - 80km LR2 (ERmin=10dB, Pavg=0dBm)
- **1550nm 10GbE optics:**
  - 40km ER/EW: (ERmin=3.0dB, Pavg=+4dBm)
  - 80km ZR/ZW: (ERmin=9dB, Pavg=+1dBm)

A Review of Tx launch power (continued)

Referring to 1G EPON and GPON

- 1.25G/1.25G EPON optics:
  - PX10: 1310nm (ERmin 6dB, Pmin -1dBm)
    1490nm (ERmin 6dB, Pmin -3dBm)
  - PX20: 1310nm (ERmin 6dB, Pmin -1dBm)
    1490nm (ERmin 6dB, Pmin +2dBm)
- 2.488G/1.244G GPON optics:
  - Class B: 1310nm (ERmin 10dB, Pmin -2dBm)
    1490nm (ERmin 10dB, Pmin +5dBm)
  - Class C: 1310nm (ERmin 10dB, Pmin +2dBm)
    1490nm (ERmin 10dB, Pmin +3dBm)
  - Class B+: 1310nm (ERmin 10dB, Pmin 0dBm)
    1490nm (ERmin 10dB, Pmin +4dBm)

Overall Pmin of +1 to +5dBm is reasonable.

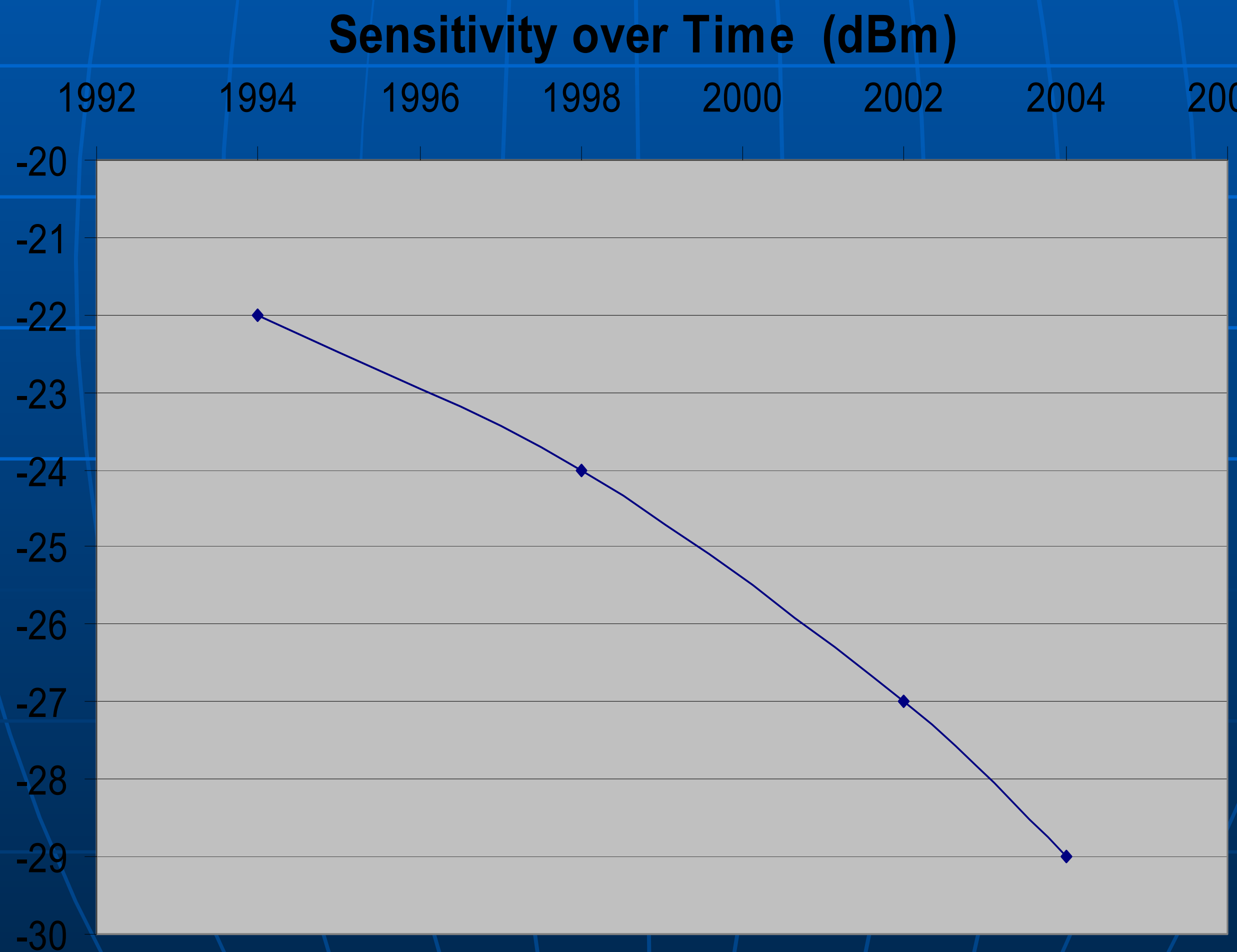
Future trends count on on-chip integration of SOA gain with min. cost premium.

ROSA Sensitivity over time

- 1Gb/s ROSAs have improved in sensitivity over the last 10-12 years at the rate of about 9dB/decade as illustrated by the chart on the next page.
- There exists similar trend for 10G ROSA(PIN) sensitivity. Since 2002, <u>off-the-shelf</u> ROSA sens. has improved from less than -18dBm to anywhere between -20 to -21dBm for now.
- Extrapolating this to 10Gb/s ROSAs would suggest that their nominal sensitivity would be about -22 to -23dBm by 2010 when the standard comes out, and probably –26 to -27dBm(?) by 2016.

1Gb/s ROSA performance over time

- 1500-1550nm
- BER = 10^{-12}
- PD responsivity ~1A/W



More on 10Gb/s ROSA Sens.

- Rx front-end sens. improvements possible by better controlling noise, jitter and bandwidth; and taking advantage of equalization techniques.

  Referring to historical academic achievable numbers

Table 1.3 **Experimental Receiver Sensitivities**

No.	*Bitrate (Gb/s)*	*Sensitivity (dBm)*[1]	*Type of Receiver*	*Reference*
1	10	−16.1	PIN-HEMT OEIC	Takahata et al. (1996)
2	10	−17.3	PIN-HEMT OEIC	Akatsu et al. (1993)
3	10	−19	PIN-HBT	Sieniawski (1998)
4	10	−20.4	PIN-HBT	Yun et al. (1995)
5	10	−22.4	PIN-HEMT	Tzeng et al. (1996)
6	10	−23.5	PIN-HEMT	Yun et al. (1995)
7	10	−26	APD-HEMT	Itzler (2000)
8	10	−27.8	APD	Clark et al. (1999)
9	10	−28.1	APD-HBT	Yamashita et al. (1997)
10	10	−28.7	APD-HEMT	Tzeng et al. (1996)
11	10	−29.2	APD	Nakata et al. (2000)
12	10	−29.4	APD-HEMT	Yun et al. (1996)
13	8	−29.5	SOA[2]	Jopson et al. (1989)
14	10	−33.0	SOA[2], RZ[3]	Smets et al. (1997)
15	10	−36.8	Raman amplifier	Nielsen et al. (1998)
16	10	−37.2	EDFA	Park and Granlund (1994)
17	10	−38.5	EDFA	Nakagawa et al. (1996)
18	10	−40.1	EDFA	Livas (1996)
19	5	−40.5	EDFA	Park and Granlund (1994)
20	5	−45.6	EDFA	Caplan and Atia (2001)
21	20	−29.9	EDFA	Fukuchi et al. (1995)
22	40	−26.6	EDFA	Kuwano et al. (1996)
23	40	−27.7	EDFA	Yonenaga et al. (1998)
24	40	−28.2	EDFA	Ohhira et al. (1998)
25	40	−30.5	EDFA	Ludwig et al. (1997)
26	100	−24.6	EDFA	Takara et al. (1998)

[1] $\mathcal{P}$ for 1×10^{-9} BER.
[2] Semiconductor optical amplifier.
[3] Return-to-zero pulse format.

Summary

- The industry has shown a history of these sensitivity improvements. It is suggested that the 10GEPON TF take advantage of the advances in receiver sensitivity and transmitter output power improvements and use them in a forward-looking manner.

- Note that even if no improvements in receiver technology occur, there is still a solution (APDs) which will allow implementation, albeit at higher cost. This unlikely to happen. As a result, there is no downside to specifying aggressive receiver sensitivity.

- Experience at the 1Gb/s level has shown that raising the bar simply provides manufacturers with a goal to meet, and has the overall effect of speeding up development.