Specifying Optical Modulation Amplitude instead of Extinction Ratio

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Some OMA History

- *Adopted by Hippi-6400-Opt (12-wide laser arrays at 1 Gbps).*
  - *Suggested by Mike Dudek, Cielo.*
  - *Proposed by Steve Joiner, HP.*
  - *Motivated by difficulty of maintaining high extinction ratio of laser array over temperature.*
- *Adopted by Fibre Channel optical working group June 1999.*
  - *Proposed by Tom Lindsay, Vixel.*

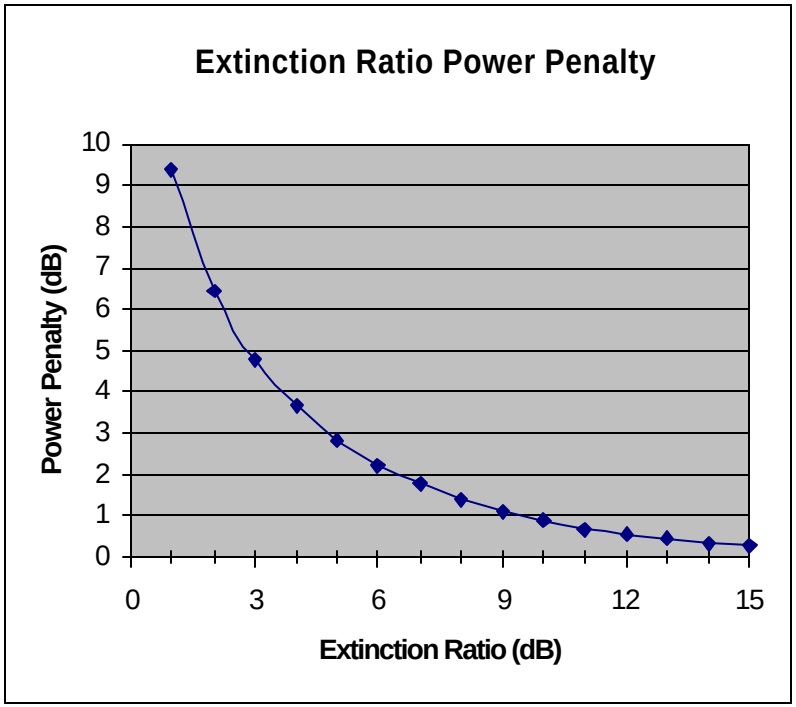
Extinction Ratio Power Penalty

- *Recognizes power in '0' bit is wasted.*
- *Usually attributed to receiver sensitivity.*

$$\text{Power Penalty} = 10 \log \frac{\frac{P_1}{P_0} - 1}{\frac{P_1}{P_0} + 1}$$

$$\text{where ER} = 10 \log \frac{P_1}{P_0}$$

1.1 dB @ 9 dB ER
2.2 dB @ 6 dB ER
4.8 dB @ 3 dB ER



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Optical Modulation Amplitude

Optical modulation amplitude is defined as the difference in power between the logic 1 and logic 0 levels.

$$OMA = (P_1 - P_0)$$

To convert from average power A and extinction ratio to optical modulation amplitude:

$$OMA = 2A \frac{\frac{P_1}{P_0} - 1}{\frac{P_1}{P_0} + 1} \qquad \text{where } 2A = P_0 + P_1$$

Optical Modulation Amplitude - Justification

- *Photoreceivers respond to signal swing not average power.*
  - *Differential input. Circuitry responds the same to:* ‘0’ = 0 μW, ‘1’ = 40 μW
    ‘0’ = 40 μW, ‘1’ = 80 μW
- *Receivers are dominated by thermal noise.*
  - *Additional shot noise at higher currents negligible.*

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Optical Modulation Amplitude - Why?

- *More freedom to set bias and modulation currents in transmitter* ⇒ lower cost.
  - Trade-off between ER and jitter.
  - Trade-off between ER and min. avg. power (when absorbing ER power penalty in transmitter budget).
- *May need lower extinction ratios at 10 Gbps.*
  - Laser turn on delay induced jitter (set ‘0’ bit bias current just above laser threshold current)
  - May help reduce chirp.
- *Receiver performance not compromised.*
  - ER power penalty absorbed by transmitter.

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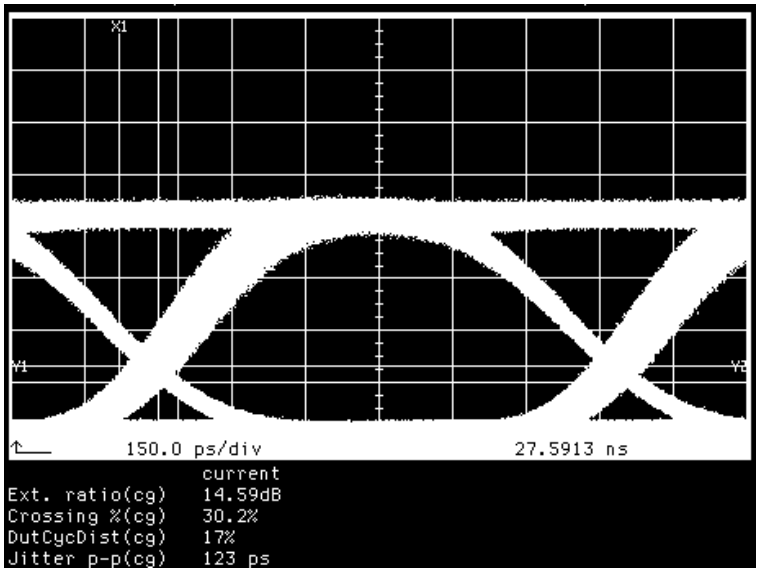
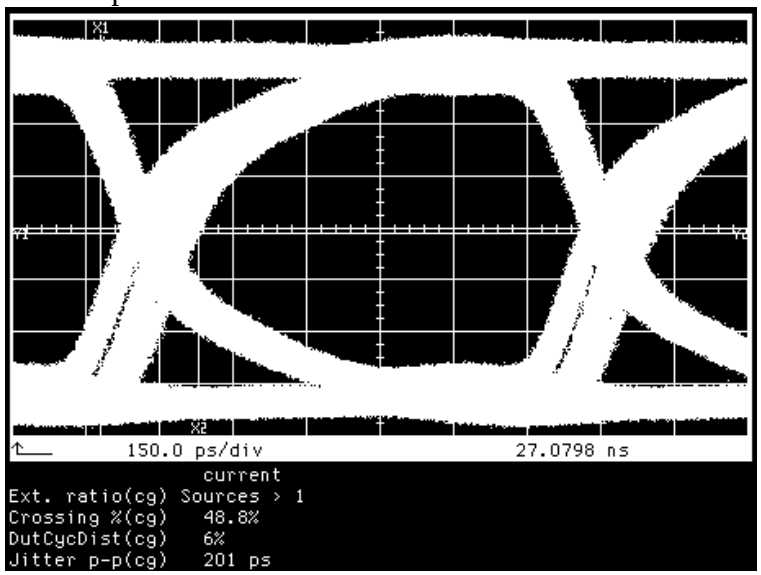
Effect of laser bias -- the benefits of specifying OMA

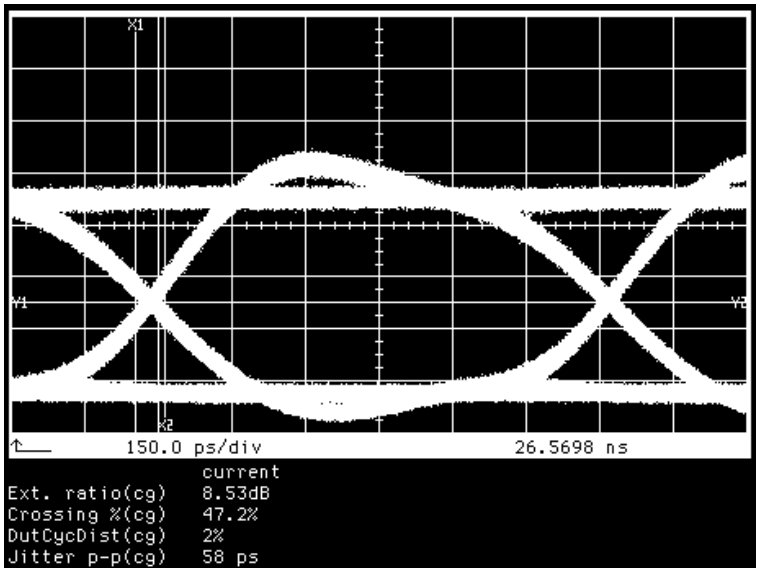
Low bias filtered Tx



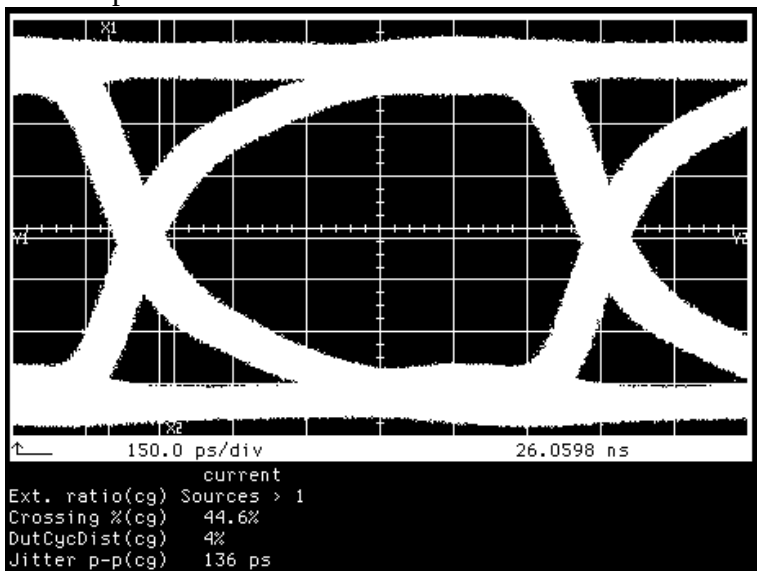
Rx output from low bias Tx



Med bias filtered Tx

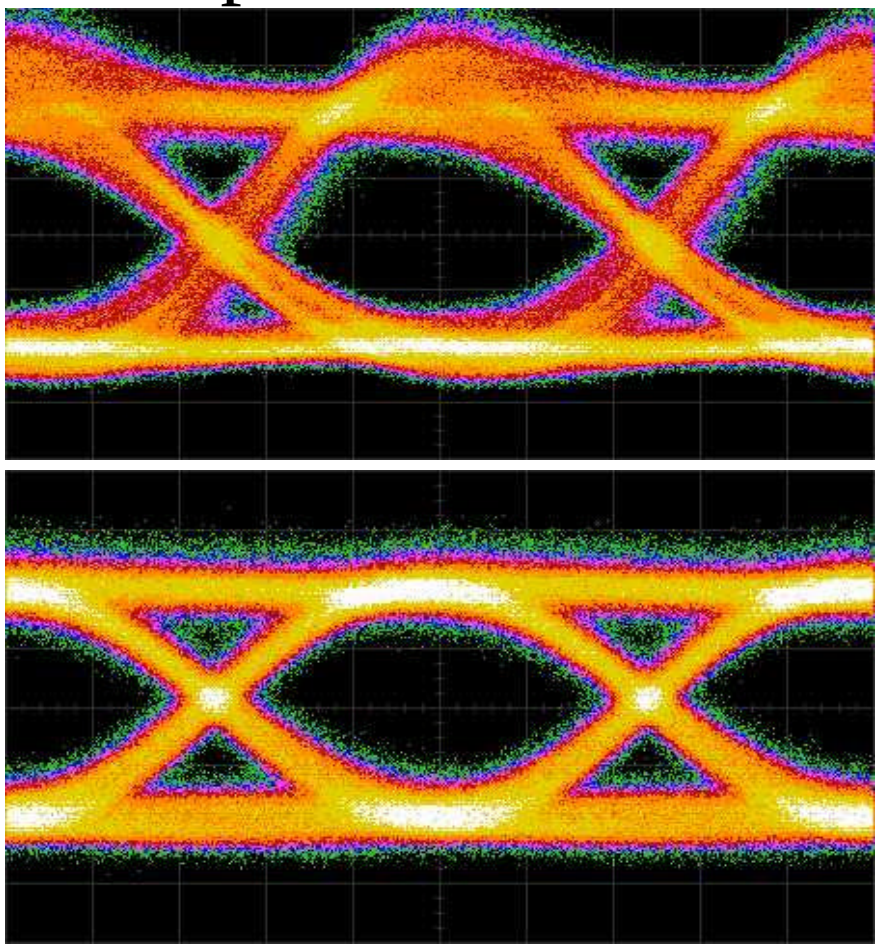


Rx output from med bias Tx



Biasing above threshold helps even for fast, low turn on delay lasers

10 Gbps 850nm VCSELs



Biased below threshold

Biased above threshold

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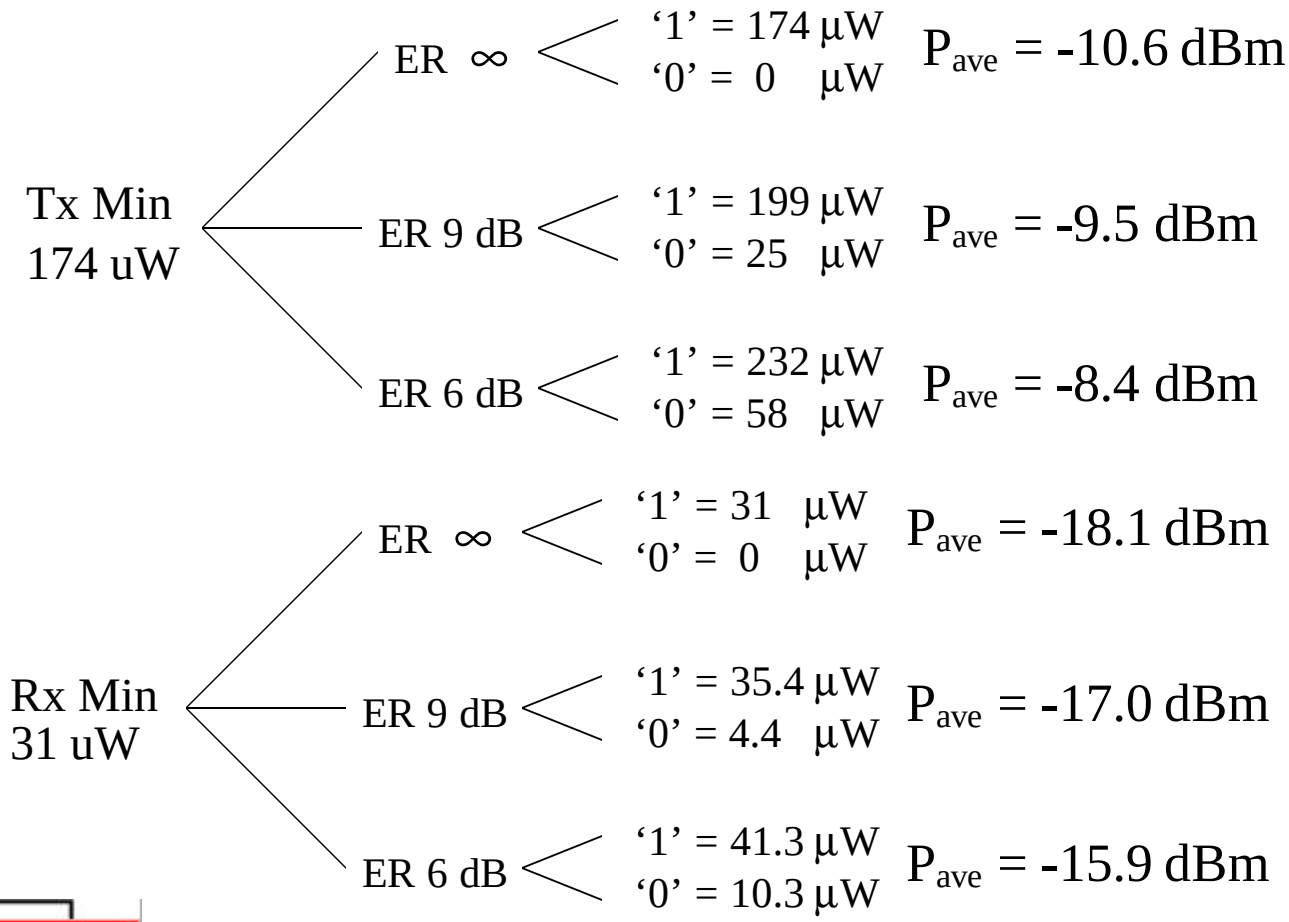
Example GbE 1000SX budget

For -9.5 dBm to -17 dBm at 9 dB ER: 174 µW to 31 µW



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Proposal for 10GbE

- *Consider specifying Tx and Rx minimum optical modulation amplitudes instead of extinction ratio.*
  - *Address technical and marketing concerns over reflector.*
  - *Make a motion at November, 1999 meeting.*
- *Monitor OMA progress in Fibre Channel and Hippi-6400-Optical standards.*
  - *Currently working through issues.*

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