OMA sensitivity ER dependency

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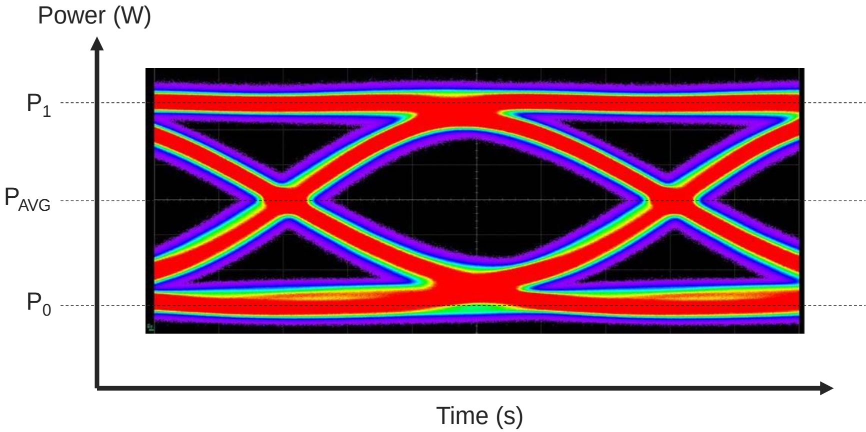
OMA sensitivity



$$OMA = P_1 - P_0 \text{...(1)}$$

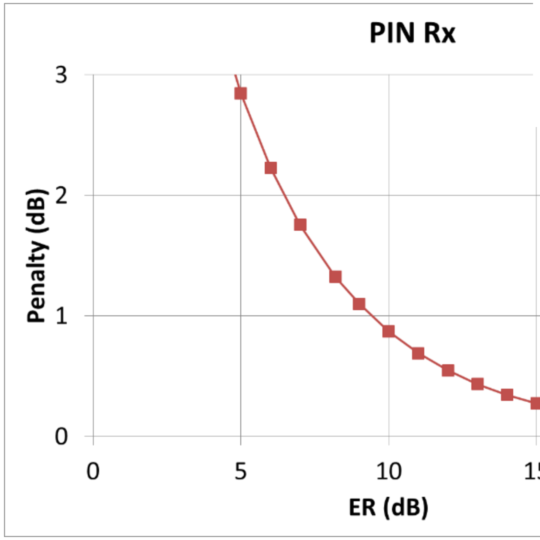
$$ER = \frac{P_1}{P_0} \text{...(2)}$$

$$P_{mean} \approx \frac{P_1 + P_0}{2} \text{...(3)}$$

$$OMA \approx 2 * P_{mean} * \frac{ER - 1}{ER + 1} \text{...(4)}$$

Optical Communication Receiver Design S. B. Alexander

- For PIN receiver , the OMA sensitivity is independent with the signal extinction ratio.
- A Pin receiver can detect a certain "1" and "0" signal difference, no matter what's the AVP of signal is.



$$P_{loss} = \frac{1+\varepsilon}{1-\varepsilon}.$$

OMA sensitivity dependency with ER for Receiver with amplification effect

power penalty from any ER less than infinity: $\epsilon = P_0/P_1$

PIN : $$P_{\text{loss,PIN}} = \frac{1+\epsilon}{1-\epsilon}$$ ………………… OMA constant

APD: $$P_{\text{loss,APD}} = \frac{1+2\epsilon}{1-2\epsilon}$$ ………………… OMA dependent vs ER

Optical pre-amplified:

$$P_{\text{loss,PRE-AMP}} = \frac{1+2\epsilon+2\sqrt{\epsilon}}{1-2\epsilon}$$ ………………… OMA dependent vs ER

Source : textbook *Optical Communication Receiver Design* by S. B. Alexander

- OMA sensitivity constant is only applied to PIN receiver but not for APD receiver and pre-amplifier receivers

APD sensitivity noise model

BER equation:

$$BER_{50\%} = \frac{1}{4}\left[\operatorname{erfc}\left(\frac{I_1 - I_0}{2\sqrt{2}\sigma_1}\right) + \operatorname{erfc}\left(\frac{I_1 - I_0}{2\sqrt{2}\sigma_0}\right)\right].$$

I_1 and I_0 is the signal intensity in ones and zeros, σ_1 and σ_0 is the standard deviation of the noise power in the ones and zeros

Noise model for APD and PIN receiver:

$$N_{\text{thermal}} = 4k_B T\Delta f / R_L,$$

$$N_{\text{shot}} = 2q\Delta f M^2 F_N (I_{DC} + I_d),$$

$$N_{\text{RIN}} = RIN \cdot I_{DC}^2 M^2 \Delta f.$$

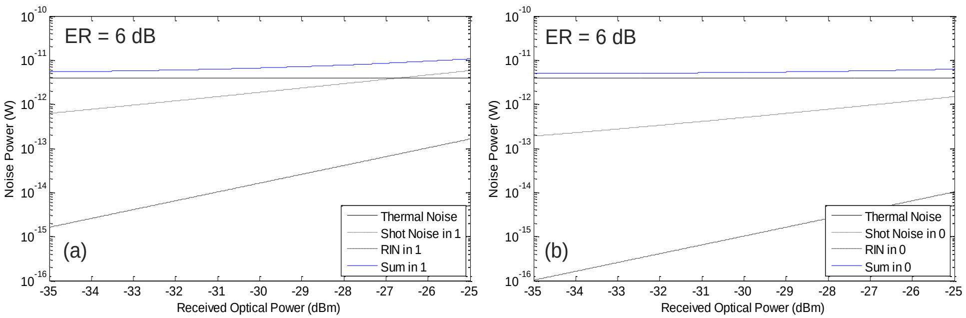
$$N_{\text{TIA}} = \int_{f_c}^{\Delta f} \left(\sqrt{\frac{(F_{TIA}-1)N_{th}}{\Delta f}\frac{f}{f_c}}\right)^2 df.$$

Noise standard deviation terms:

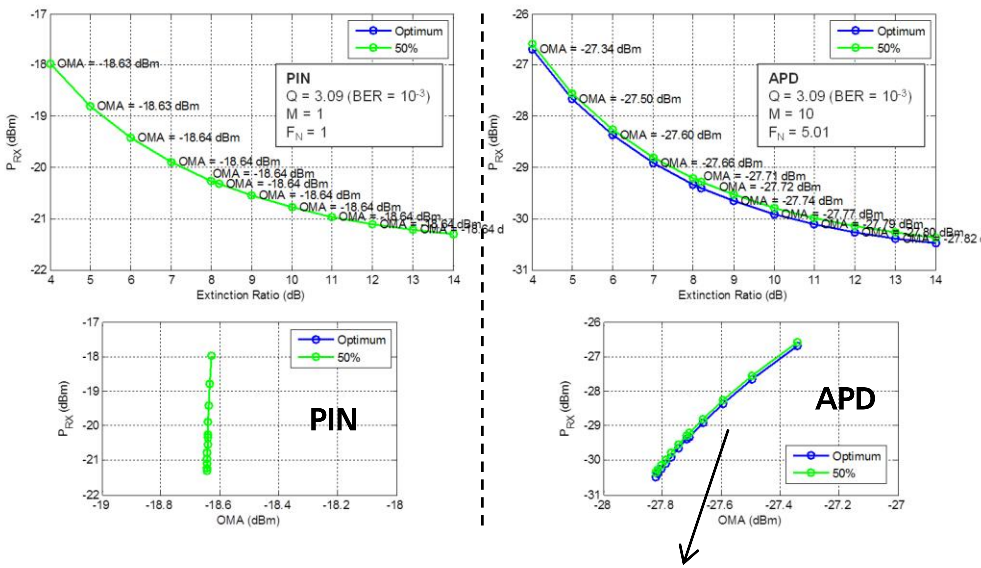
$$\sigma_1 = \sqrt{N_{\text{th},1} + N_{\text{shot},1} + N_{\text{RIN},1}}$$

$$\sigma_0 = \sqrt{N_{\text{th},0} + N_{\text{shot},0} + N_{\text{RIN},0}}$$

APD Noise power calculations

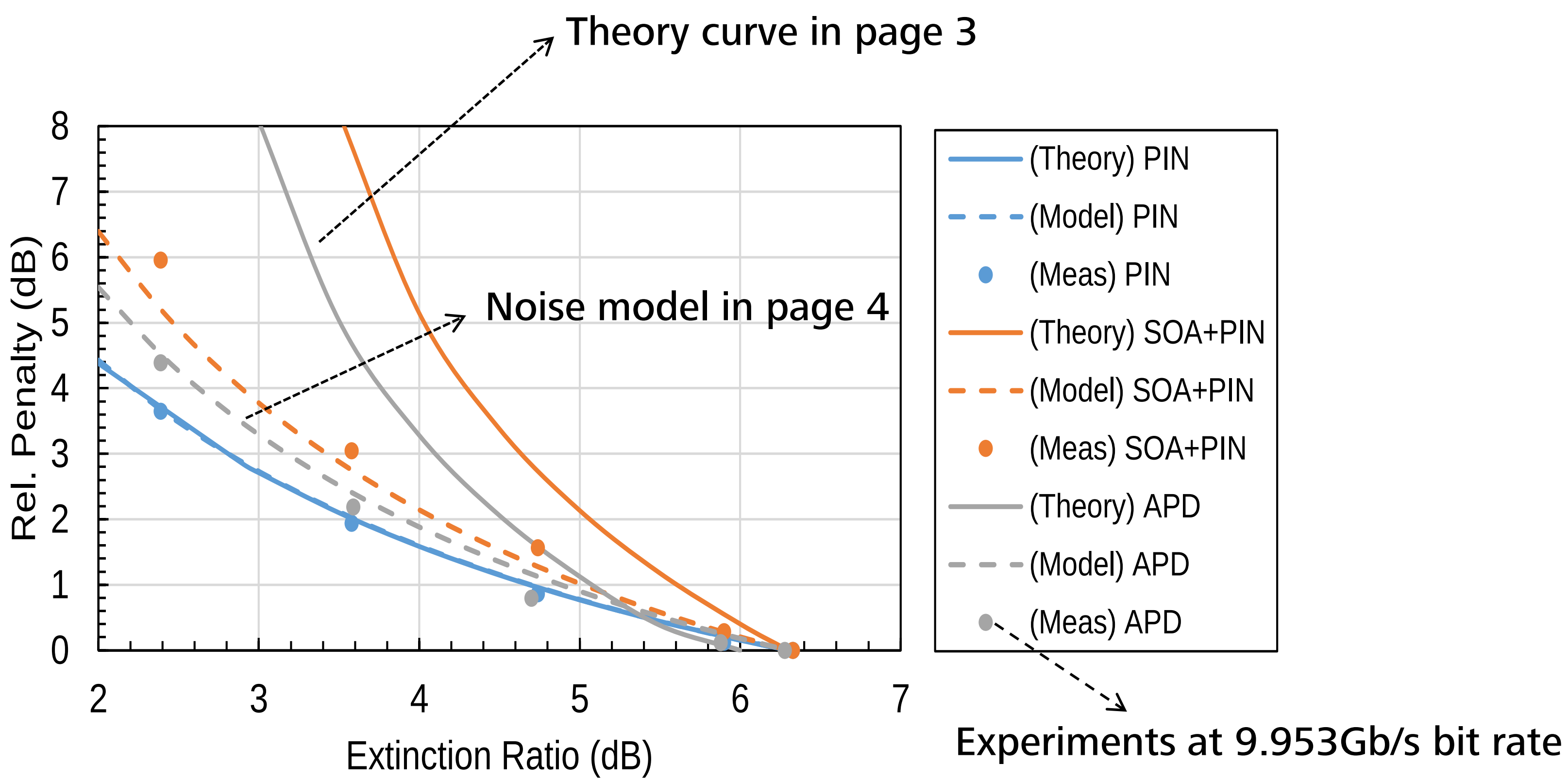


Relationship between OMA and receiver power



APD OMA is not constant!

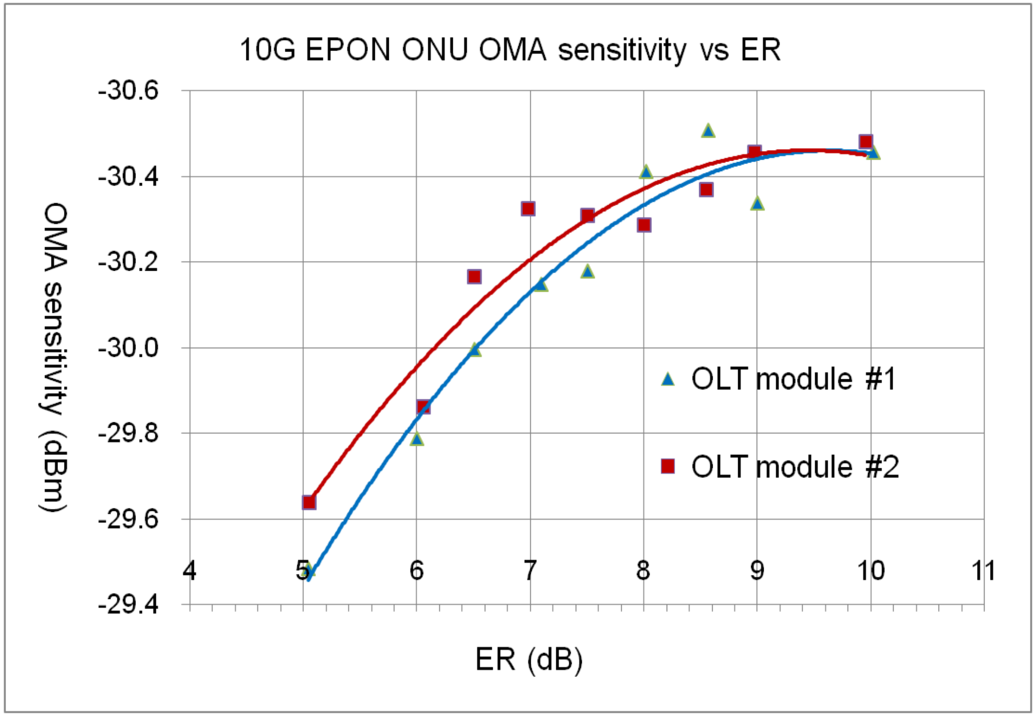
OMA sensitivity dependency comparison



Received power penalty relative to ER = 6.3 dB at 9.953Gb/s based on Mach Zhender modulator as a transmitter

10G EPON ONU sensitivity OMA measurements

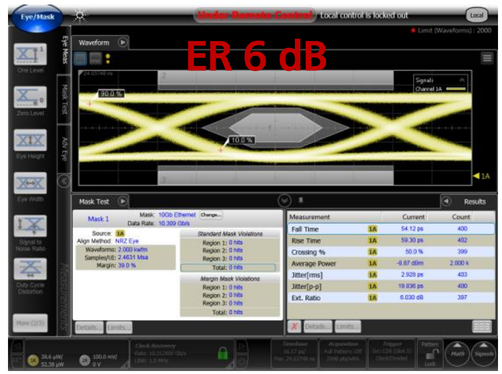
	Sensitivity (dBm)	ER (dB)	OMA sensitivity (dBm)
#1 EML	−29.7	5.0	−29.5
	−30.6	6.0	−29.8
	−31.0	6.5	−30.0
	−31.4	7.1	−30.1
	−31.6	7.5	−30.2
	−32.0	8.0	−30.4
	−32.3	8.6	−30.5
	−32.3	9.0	−30.3
	−32.6	10.0	−30.5
#2 EML	−29.8	5.1	−29.6
	−30.7	6.1	−29.9
	−31.2	6.5	−30.2
	−31.6	7.0	−30.3
	−31.8	7.5	−30.3
	−31.9	8.0	−30.3
	−32.2	8.6	−30.4
	−32.4	9.0	−30.5
	−32.6	10.0	−30.5

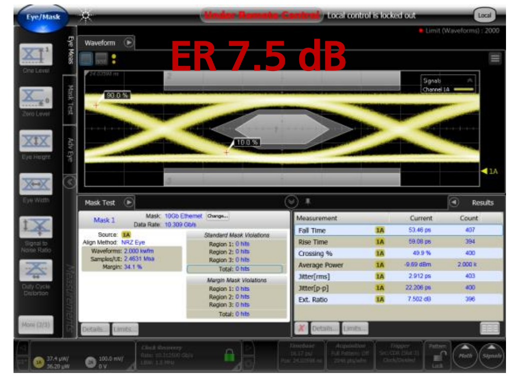


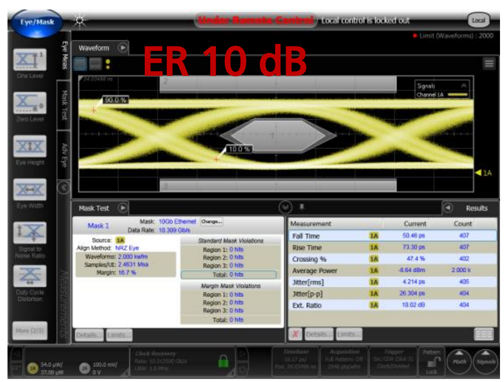
10G EPON OMA ONU sensitivity based on two 10G EPON OLT transmitter modules as the source at room temperature

- The OMA sensitivity increases as ER increases from the tendency
- Some non- monotonous variations should due to the eye diagram quality variation for 10G EML after ER changes.

OLT EML Transmitter #1 Eye diagram



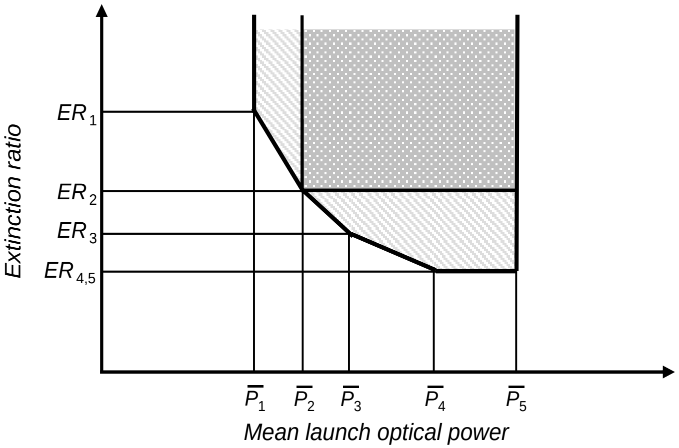




ER (dB)	Eye margin
5.04	31.20%
6	39%
7.1	39%
7.5	34.10%
8	44.60%
8.6	40.90%
9	38.10%
10	16.70%

Summary

- APD OMA sensitivity is not constant versus different ER, a constant OMA transmitter can't guarantee the compliance of power budget.
- Instead of the constant OMA way, propose to define a AVP_{min} vs ER curve for the transmitter to allow different AVP_{min} for different ER



Thank you