

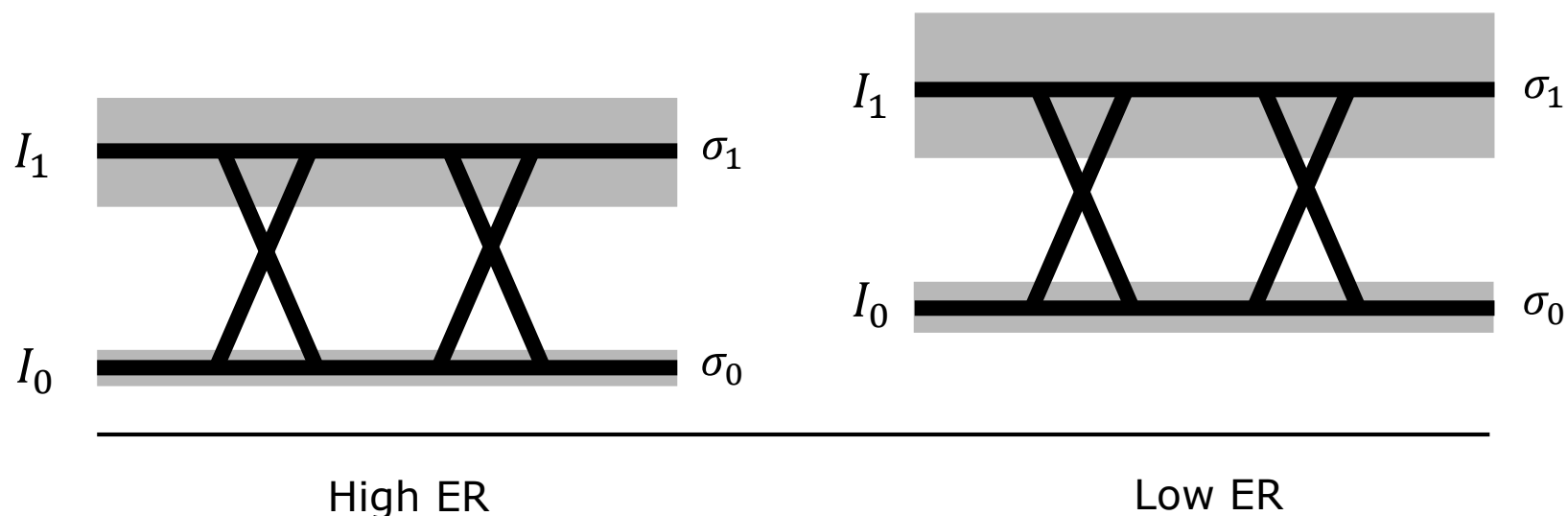
ER Dependency of APD Receiver Sensitivity

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Supporter

Motivation

- OMA sensitivity of APD receiver shows ER dependency due to APD shot noise. In this presentation, I'll show calculated ER penalties.



$$I_1 = MRP_{OMA} \frac{ER}{ER-1} \quad (\text{A})$$

$$I_0 = MRP_{OMA} \frac{1}{ER-1} \quad (\text{A})$$

R : O/E Responsivity (A/W)

M : APD multiplication gain

P_{OMA} : Received Optical Power in OMA (W)

ER : Extinction Ratio

APD Current Noise Calculation

$$\sigma_{APD} = \sqrt{2q(i + i_d)FM^2B} \quad (A)$$

q : elementary charge (=1.602x10⁻¹⁹ C)

M : APD multiplication gain

i : APD current (M=1) (A)

i_d : APD dark current (M=1) (A)

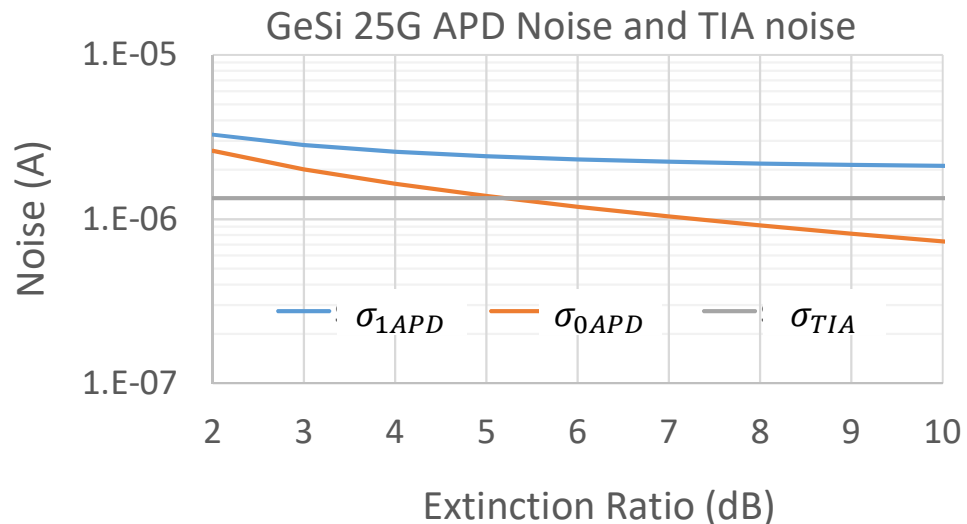
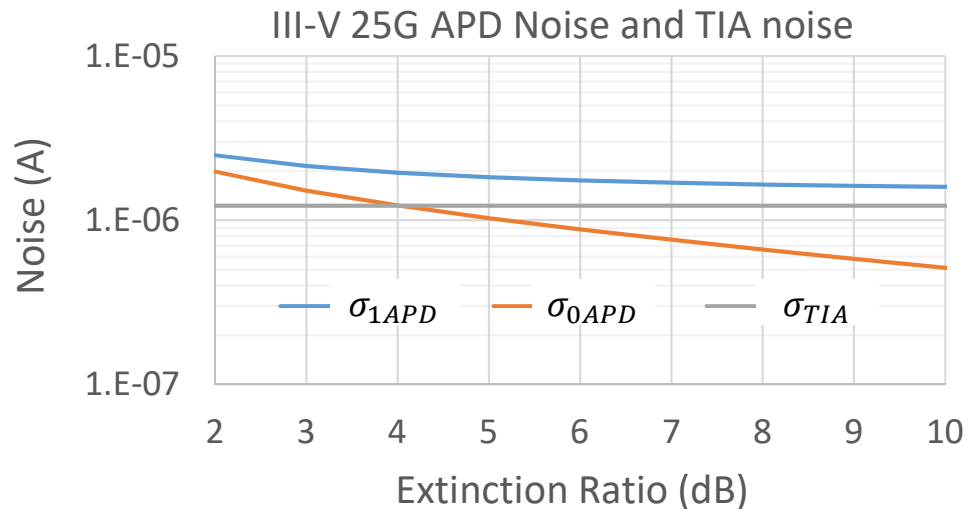
B : receiver bandwidth (Hz)

F : excess noise factor

$$F = kM + (2 - 1/M) (1 - k) \quad k : \text{ionization-coefficient ratio}$$

Reference: http://www.ieee802.org/3/ca/public/meeting_archive/2016/09/pan_3ca_1_0916.pdf

ER Dependency of APD Noise



Representative parameter values

Parameter	III-V	GeSi	Unit
$P_{OMA}^{(1)}$	-24.83		dBm
k	0.45	0.13	
$i_d^{(2)}$	10	60	nA
$M^{(2)}$	7	10	
R	0.7		A/W
$B^{(2)}$	15	18	GHz
$\sigma_{TIA}^{(3)}$	1.22	1.34	uA

Note

- (1) OLT sensitivity at BER=1e-2
- (2) GeSi APD has wider bandwidth with high M, but dark current is larger than III-IV.
- (3) Assumed TIA noise is constant over frequency for simplicity.

$$\sigma_{TIA} = 10 \text{ pA}/\sqrt{\text{Hz}} \times \sqrt{B} \quad (\text{A})$$

ER Dependency of APD Noise

Total noise of APD and TIA is:

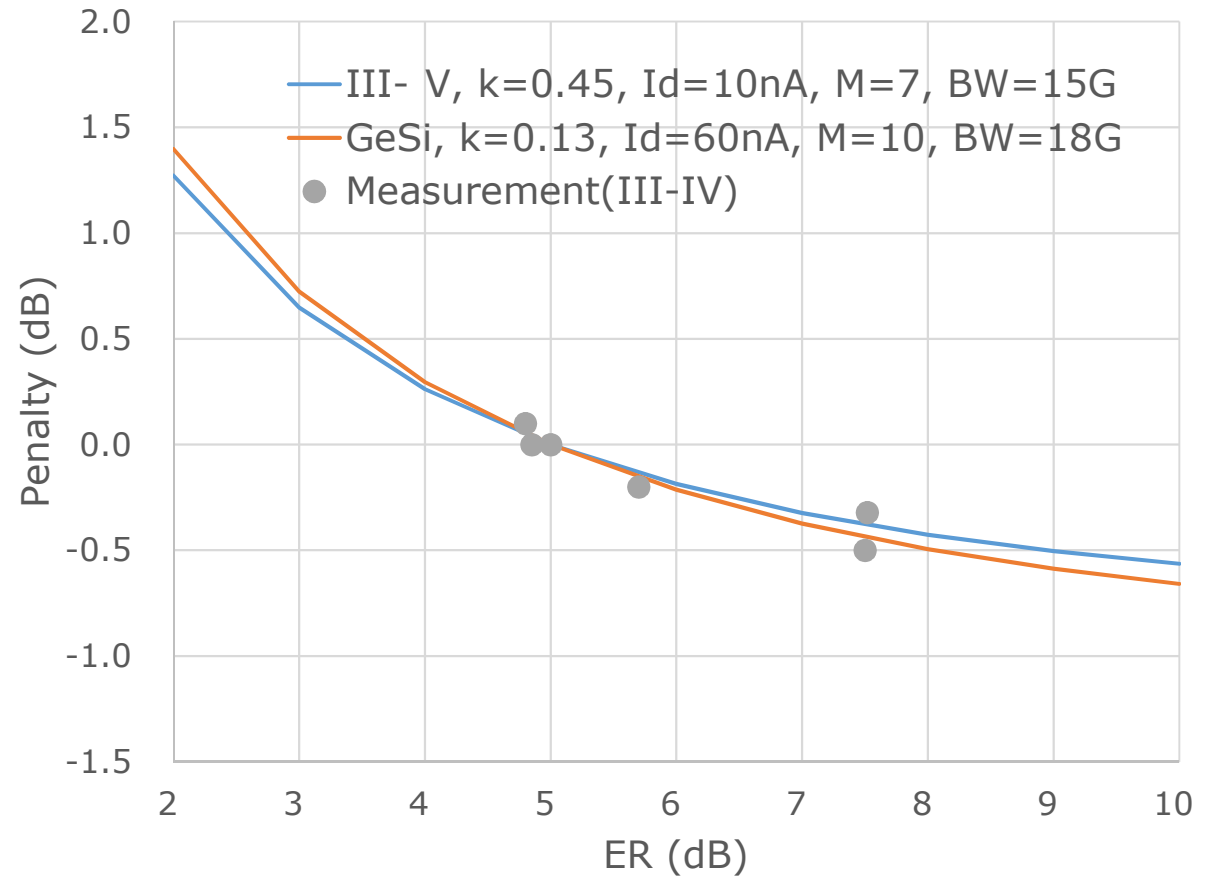
$$\sigma_1 = \sqrt{\sigma_{1APD}^2 + \sigma_{TIA}^2}$$

$$\sigma_0 = \sqrt{\sigma_{0APD}^2 + \sigma_{TIA}^2}$$

ER dependent penalty of OMA sensitivity is:

$$Penalty = 10 \log \left(\frac{Q(ER)}{Q(ER=)} \right)$$

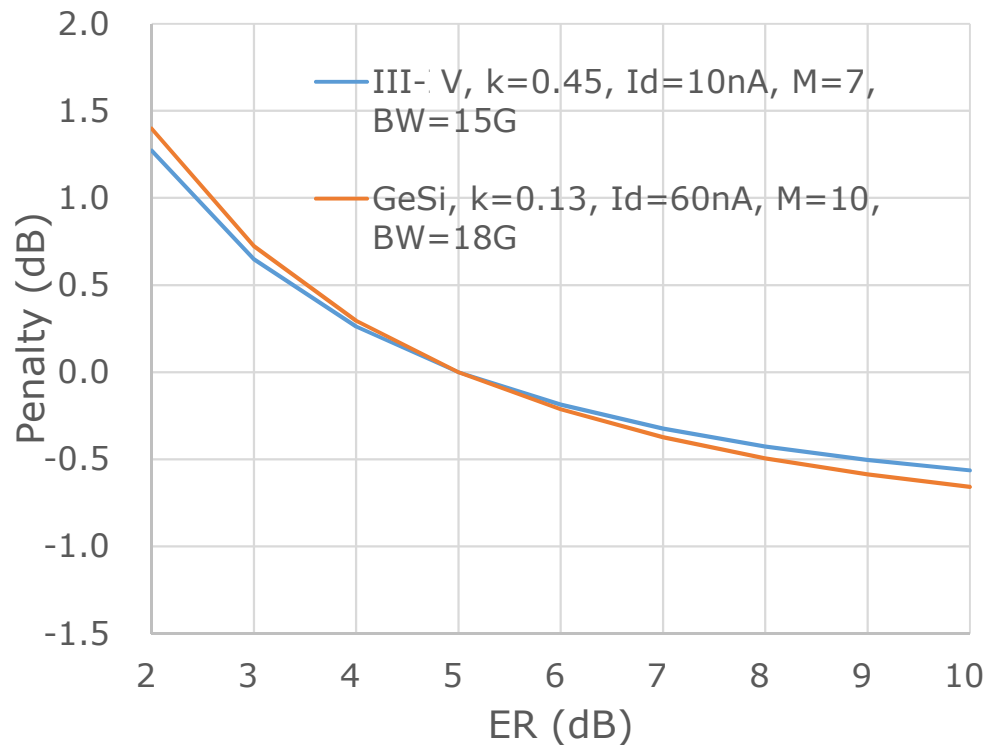
$$Q(ER) = \frac{I_1 - I_0}{\sigma_1 + \sigma_0}$$



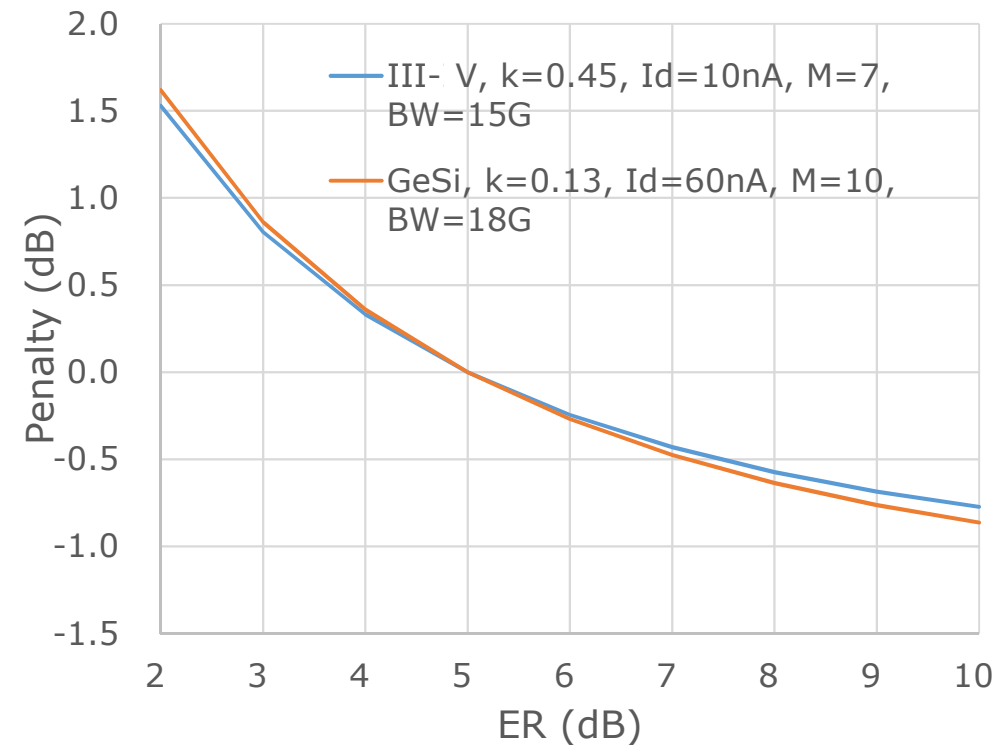
Measurement plots are from tanaka_3ca_1_1116.pdf

ER Dependency of APD Noise

The penalty has dependency on received power level.



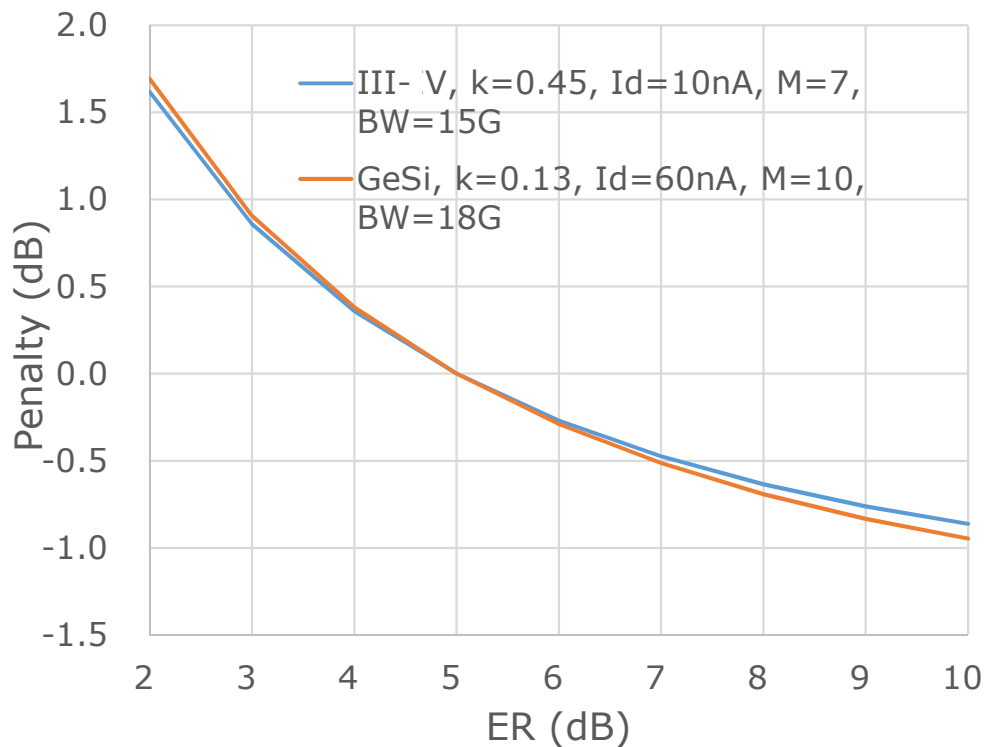
$P_{OMA} = -24.83$ dBm
(25G OLT sensitivity @BER=1e-2)



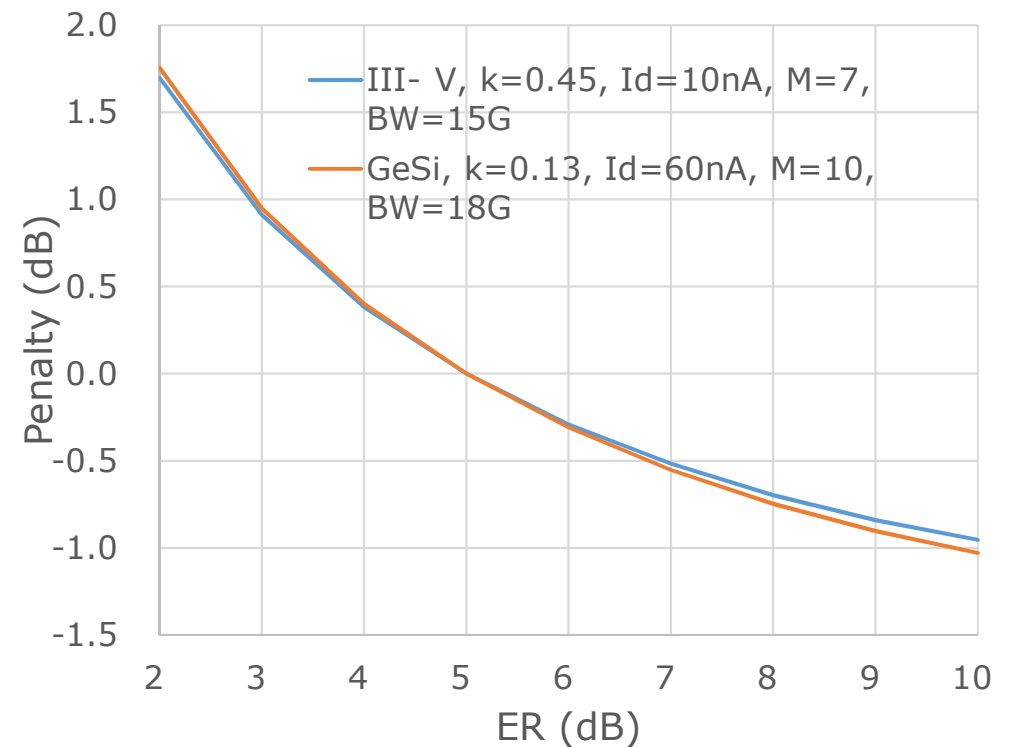
$P_{OMA} = -21.83$ dBm
(25G OLT sensitivity + 3dB)

ER Dependency of APD Noise

The penalty has dependency on received power level.



$P_{OMA} = -20.5 \text{ dBm}$
(4WDM MSA 40km)



$P_{OMA} = -19.0 \text{ dBm}$
(25GBASE-ER)

Summary

- OMA sensitivity of APD receiver has ER dependency and showed calculated ER penalties for III-V and GeSi APD.
- Need to consider the penalty to relax ER specification.