



**INSTITUTO
DE INGENIERÍA
UNAM**

**4x25-Gb/s 40-km 1310-nm PMD
with SOA Pre-Amplifier:
Variation of SOA Gain**

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(collaboration with Marcus Duelk, Bell Labs / Alcatel-Lucent)

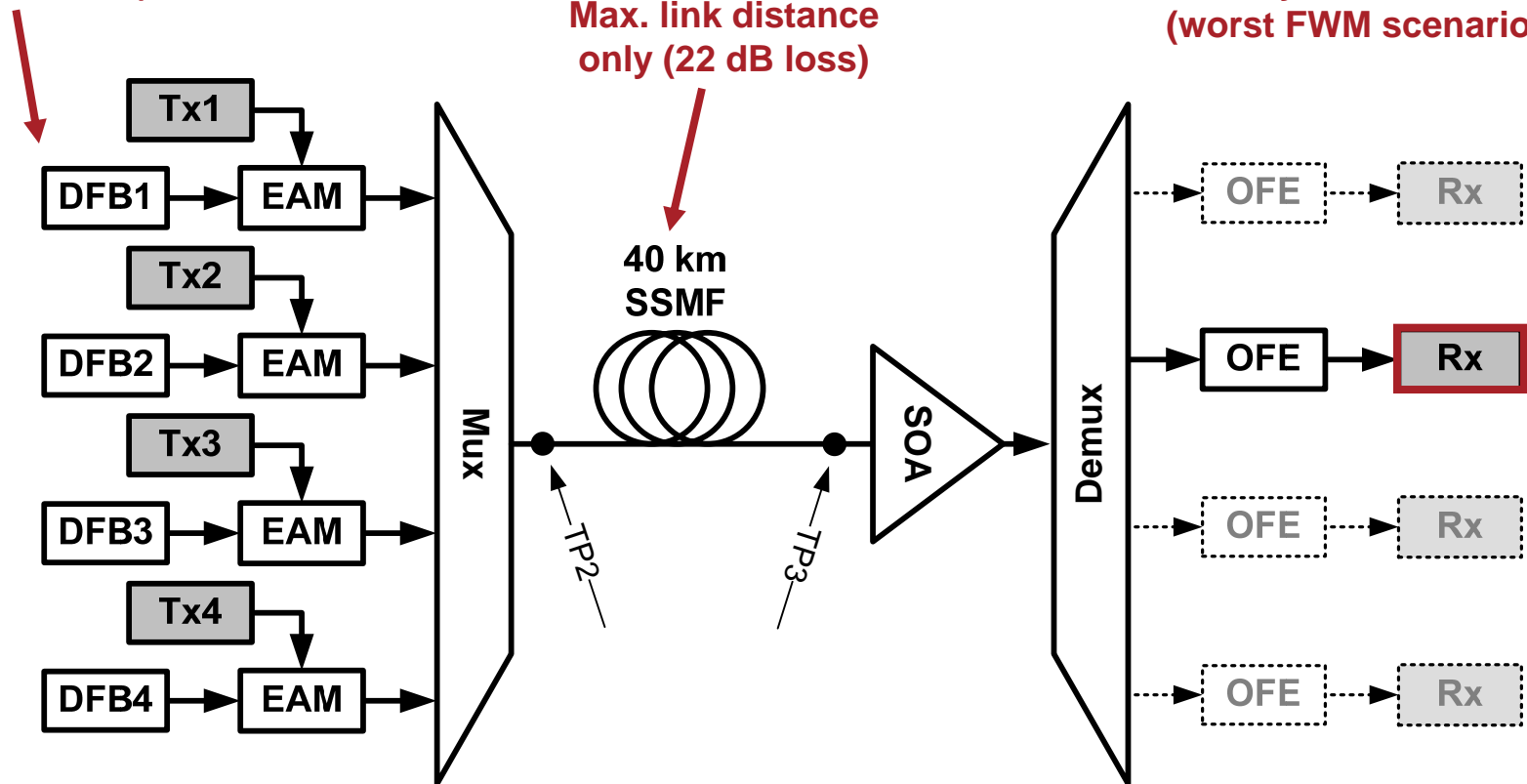


Link Configuration

Fixed Channel Spacing
(400 GHz)

Max. link distance
only (22 dB loss)

BER analysis in channel #2
(worst FWM scenario)





Optical Components Characteristics

- EML Transmitter:
 - 10 dB extinction ratio
 - 40 dB OSNR
- Optical fiber @1310 nm:
 - Attenuation = 0.5 dB/km (ITU-T G.652 Attr.A)
 - Dispersion = -0.20 ps/nm/km
 - Slope = 0.090 ps/nm²/km
 - 2-dB additional loss from connectors & splicing
- Mux/Demux (3rd order Gaussian filter):
 - 3-dB bandwidth = 175 GHz (~1.0 nm)
 - Crosstalk = 25 dB
 - Insertion loss: 3.7 dB (Mux), 5.2 dB (Demux)



Optical Components Characteristics

...cont'd

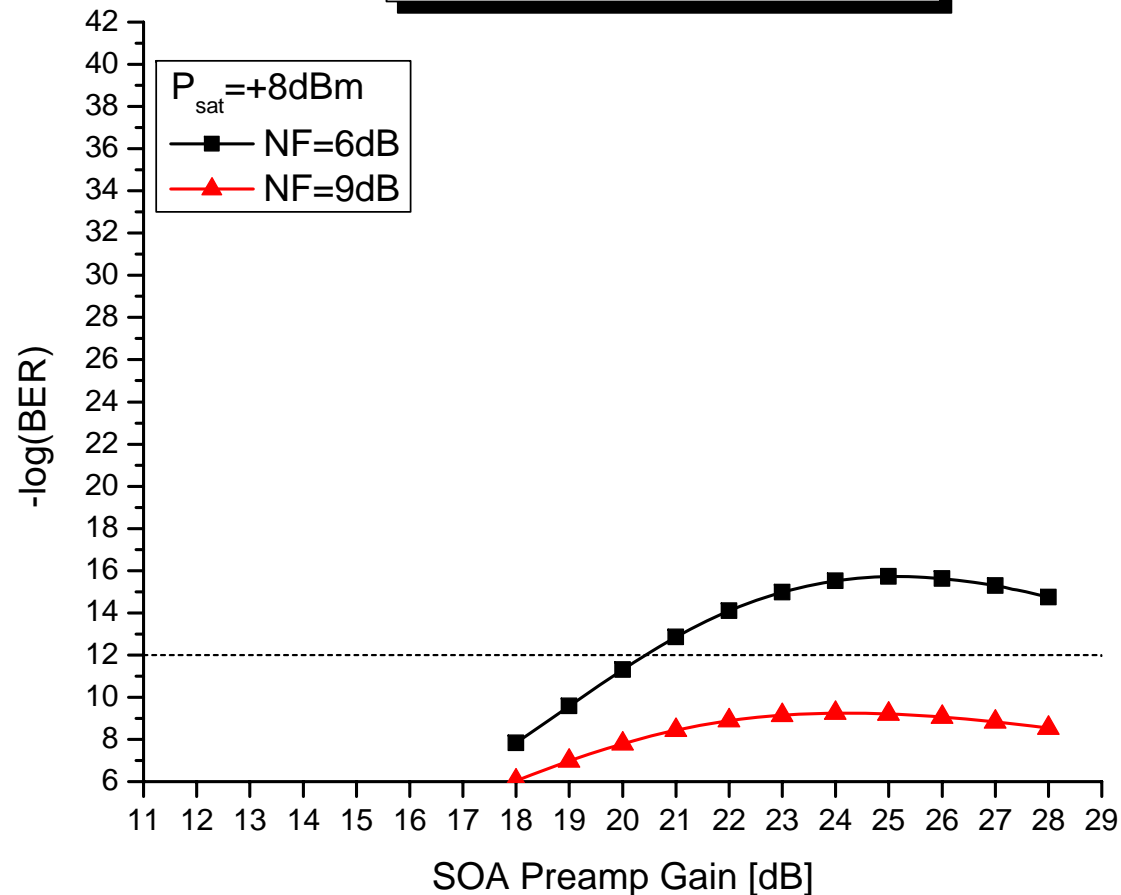
- Receiver
 - Electrical receiver bandwidth = 25 GHz (RC 5th order)
 - Random noise variance electrical Rx = $2.86 \text{ mV}_{\text{rms}}$
→ $40 \text{ mV}_{\text{pp}}$ sensitivity for BER $1\text{E-}12$
 - OFE bandwidth = 25 GHz (Bessel 5th order)
 - TIA = 1400Ω , $18 \text{ pA}/\sqrt{\text{Hz}}$
 - Photodiode responsivity = 0.7 A/W
- SOA model
 - Assumes lumped device
 - Calculates the time-evolution of the integrated gain coefficient driven by the input power $P(t)$
 - Small-signal gain, saturation power (P_{sat}), and noise figure (NF) are input parameters



EML Output Power = 0 dBm

EML = 10 dB ER, 0 dBm power

+2.3 dBm @ TP2



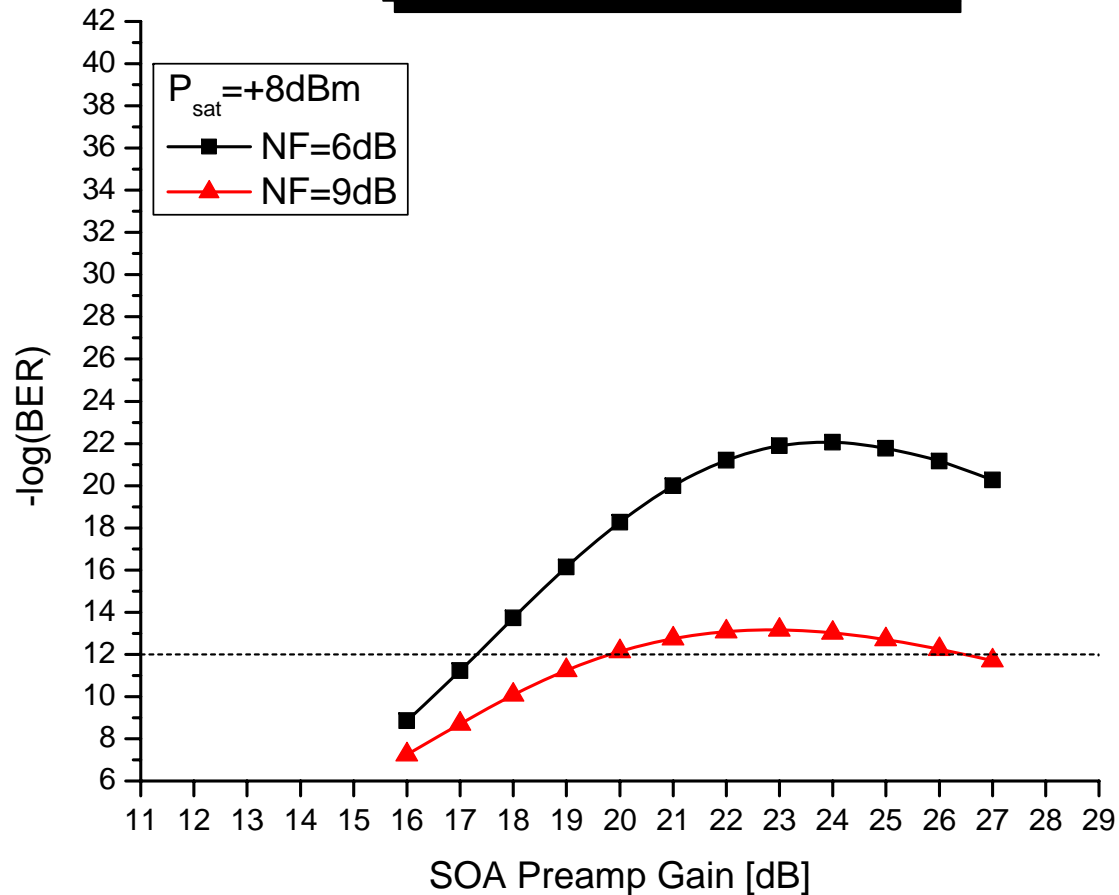
40-km link (22 dB loss)



EML Output Power = +2 dBm

EML = 10 dB ER, +2 dBm power

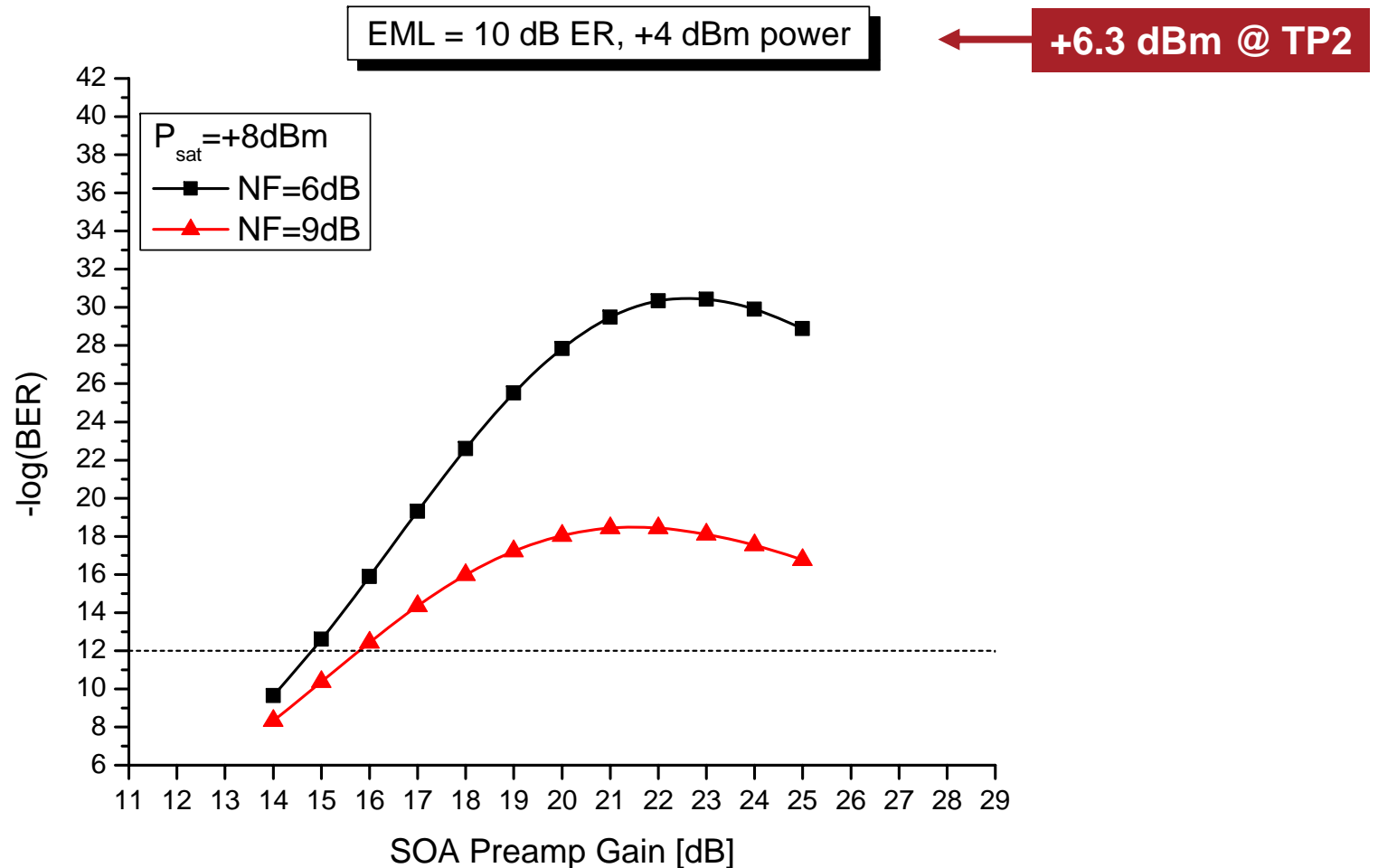
+4.3 dBm @ TP2



40-km link (22 dB loss)



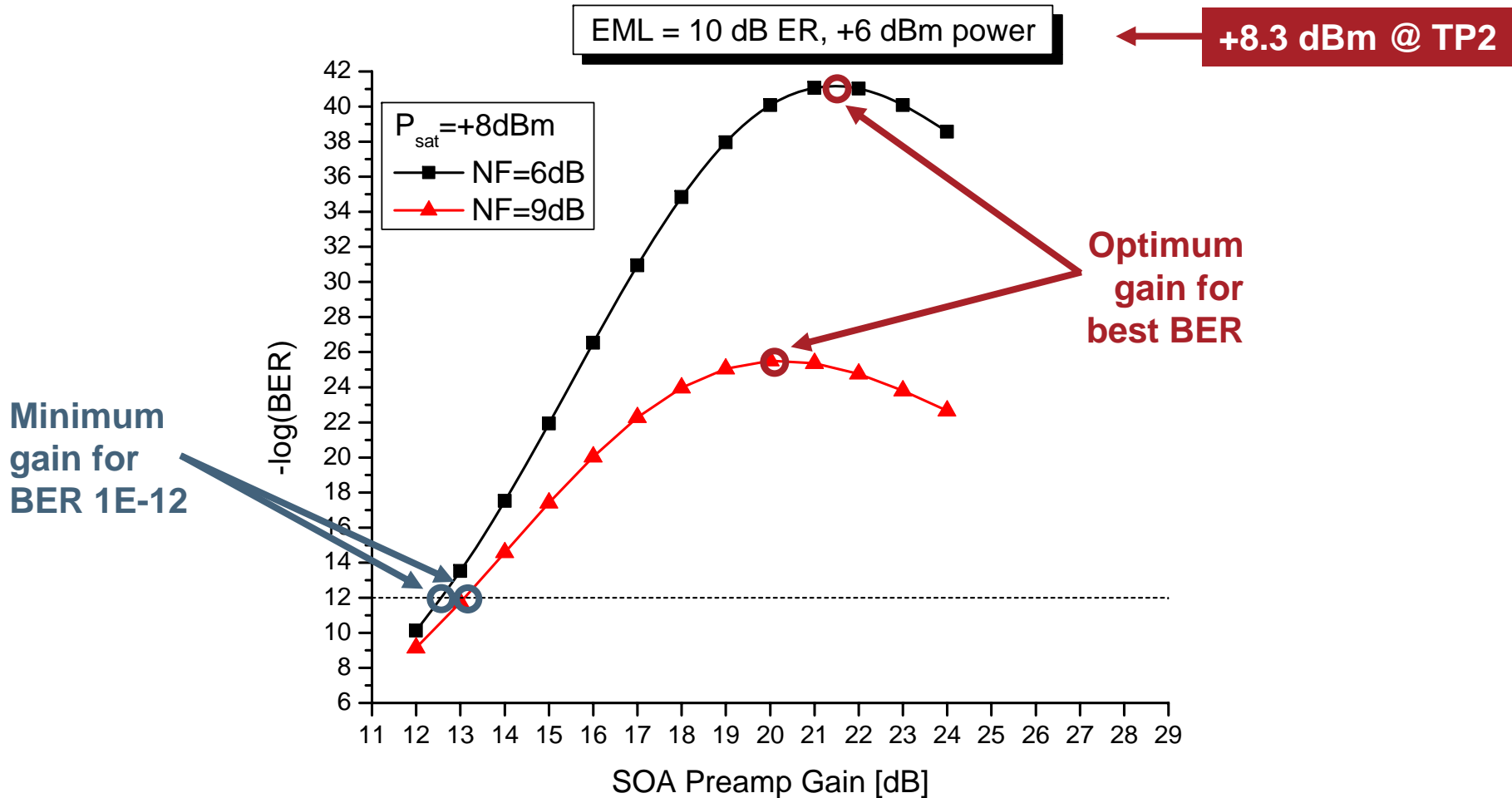
EML Output Power = +4 dBm



40-km link (22 dB loss)



EML Output Power = +6 dBm

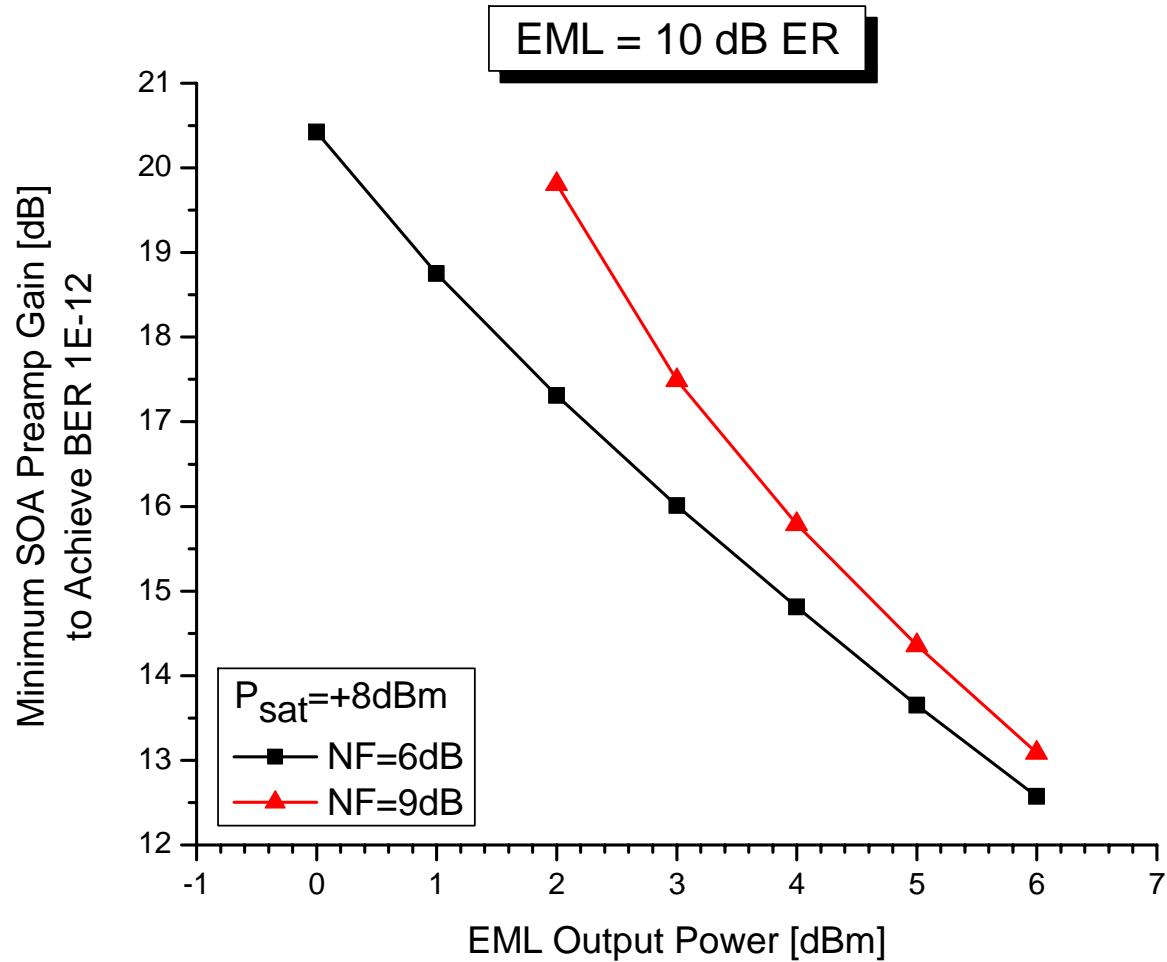


40-km link (22 dB loss)



Minimum SOA Preamp Gain for BER 1E-12

Minimum Gain

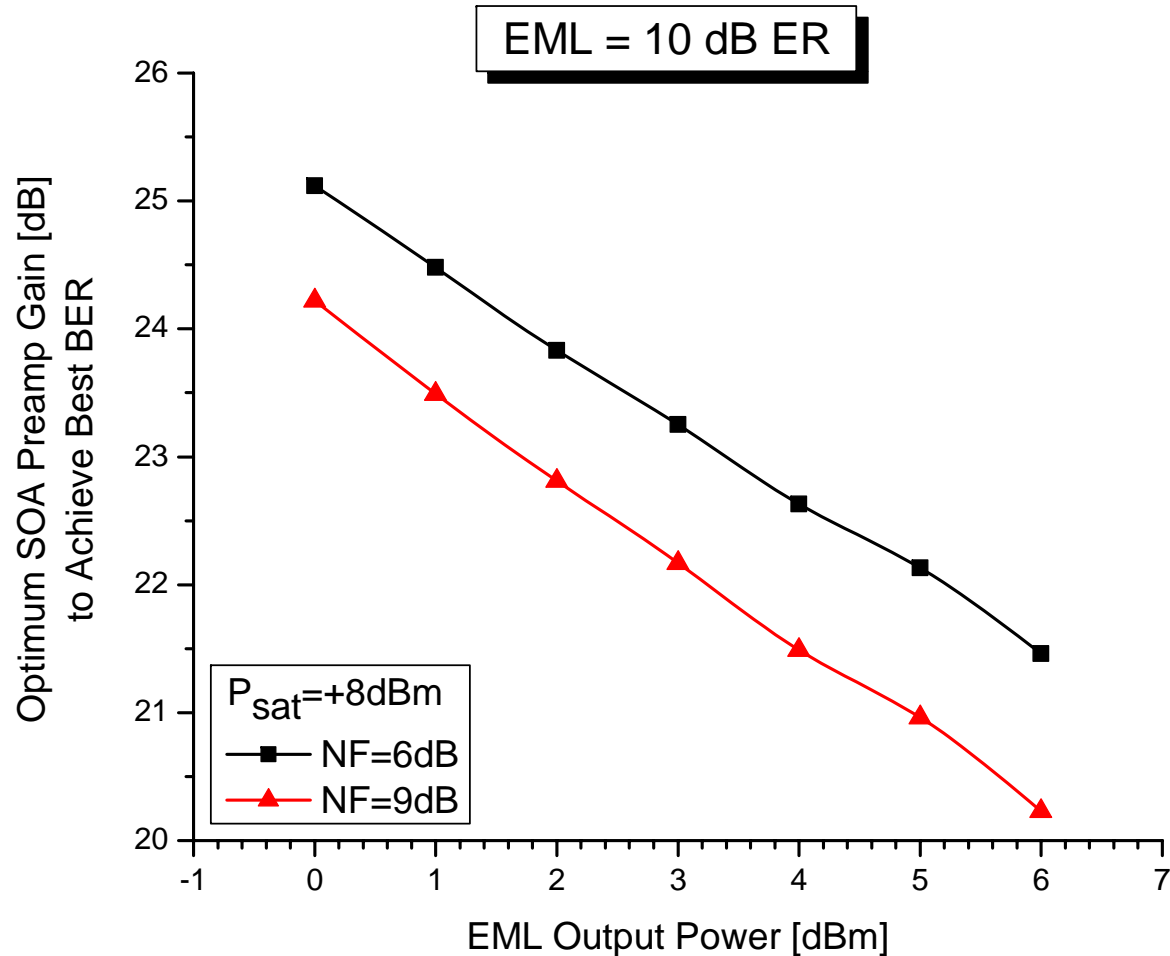


40-km link (22 dB loss)



Optimum SOA Preamp Gain for Best BER

Optimum Gain



40-km link (22 dB loss)



Conclusions

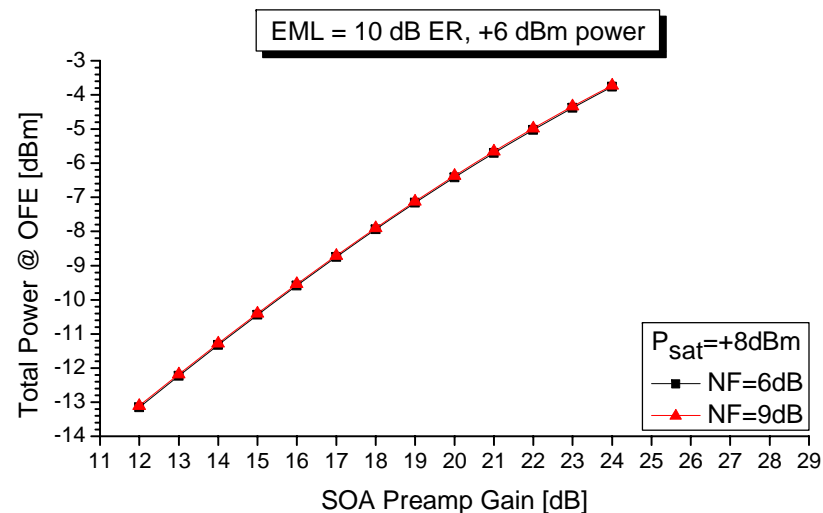
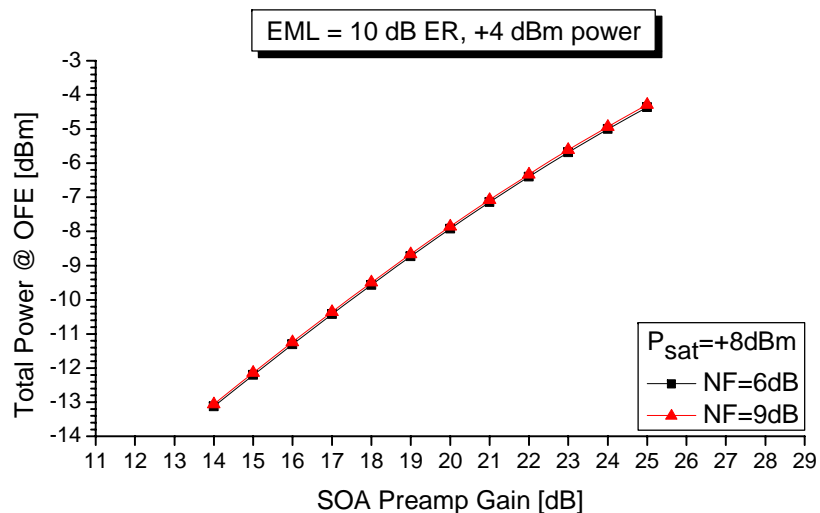
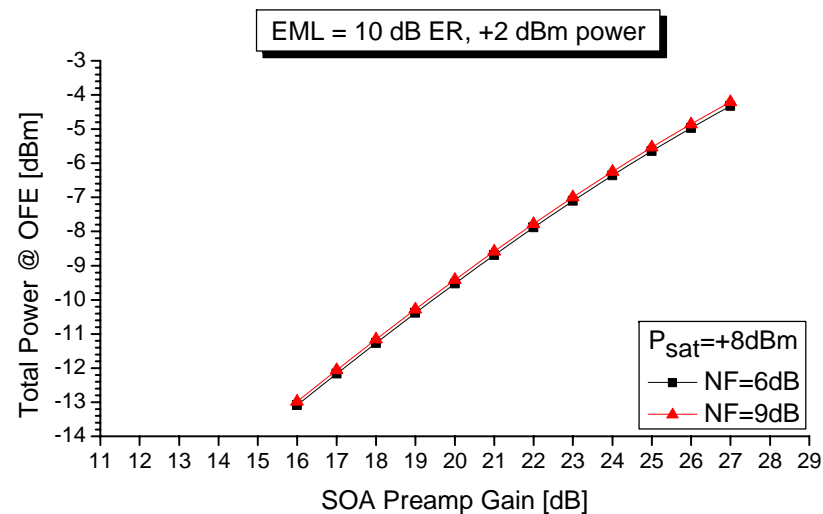
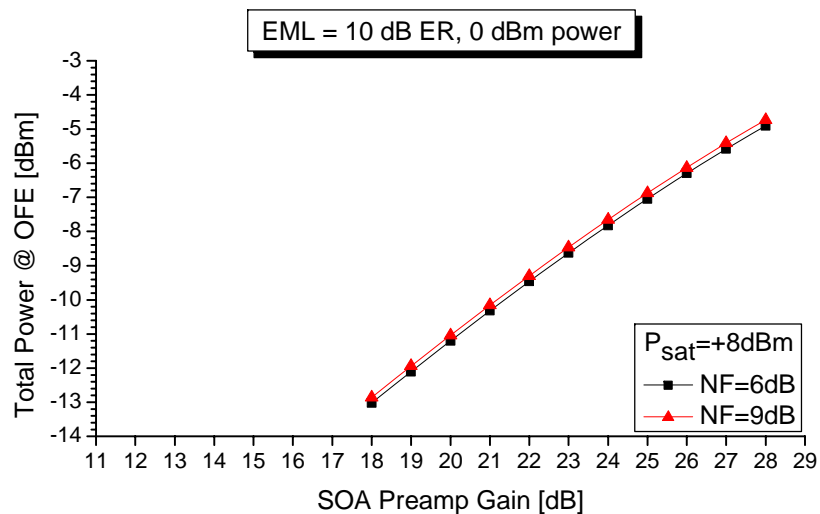
- A 40-km link (22 dB loss) with SOA pre-amplifier has been analyzed
- Using EMLs with 10-dB extinction ratio and output power between 0 dBm and +6 dBm (+2 to +8 dBm @ TP2) we found that:
 - The **minimum small-signal gain** of the SOA to achieve a BER of $1E-12$ lies between **~13 dB and ~20 dB**
 - The **best BER performance** is achieved with a small-signal gain of the SOA between **~21 dB and ~25 dB**
- An SOA with $P_{\text{sat}} = +8$ dBm and NF of 6 and 9 dB has been assumed
- The required minimum and optimum small-signal gain of the SOA pre-amplifier can be reduced by:
 - Decreasing the link loss (e.g., link length)
 - Increasing the EML output power and/or extinction ratio
 - Increasing P_{sat} (designing a SOA that is “less non-linear”)



Backup Material



Total Power @ OFE (22-dB link loss)



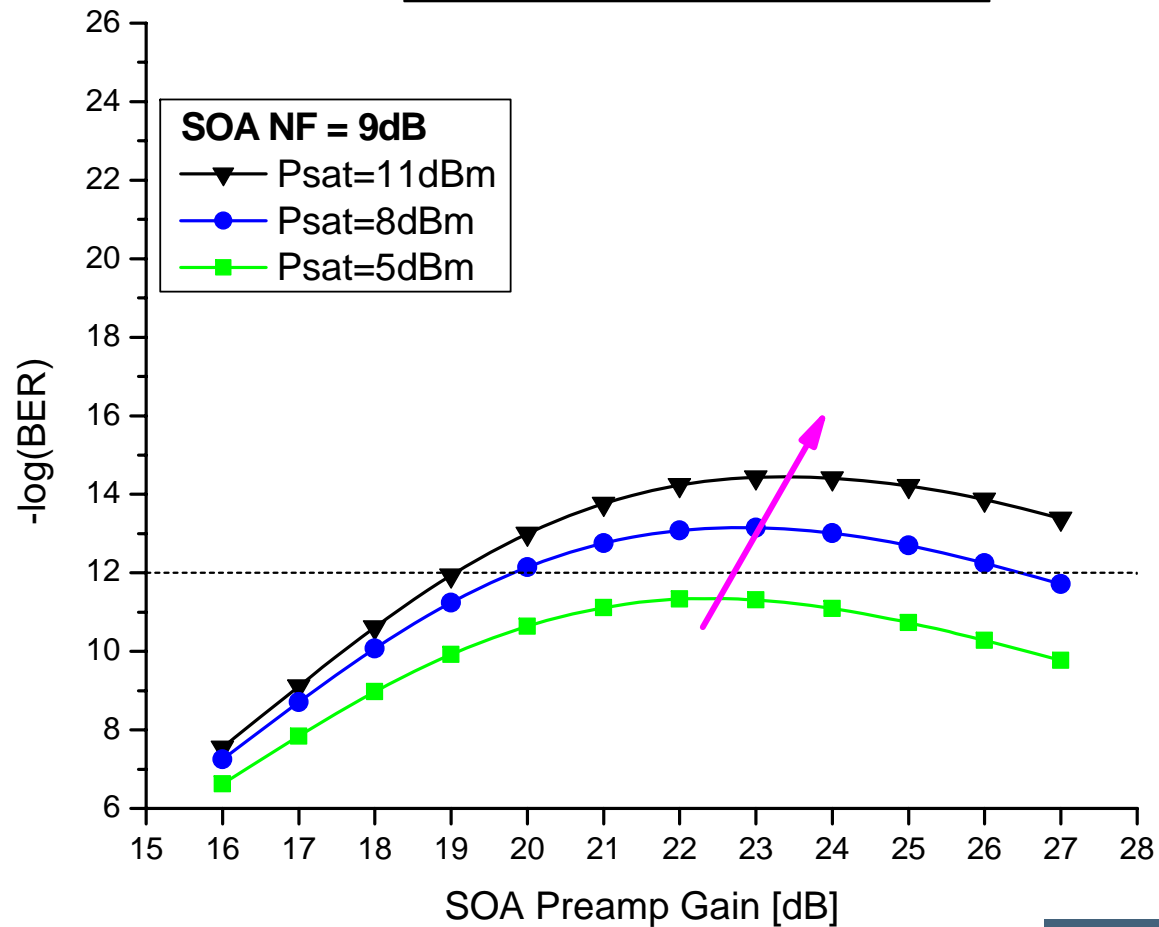


Variation of P_{sat} of SOA Pre-Amplifier



BER Performance (NF=9dB)

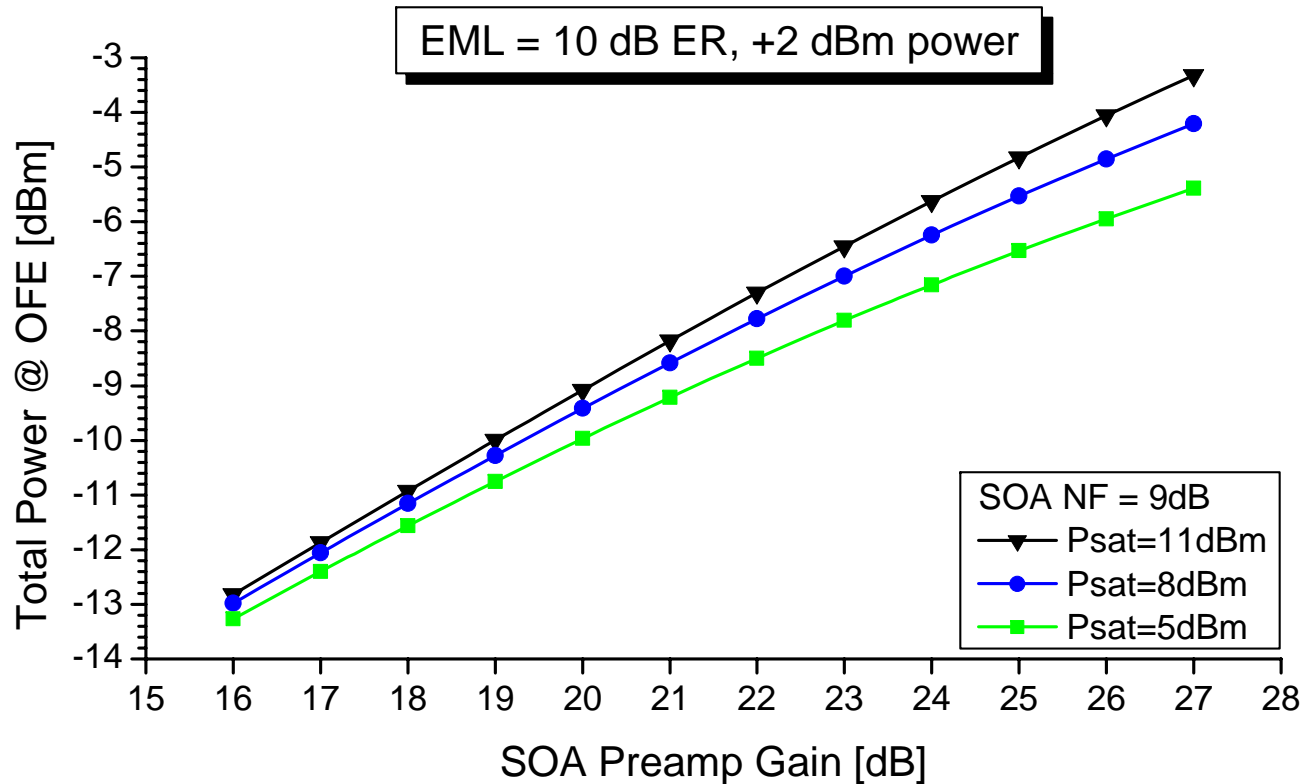
EML = 10 dB ER, +2 dBm power



40-km link (22 dB loss)



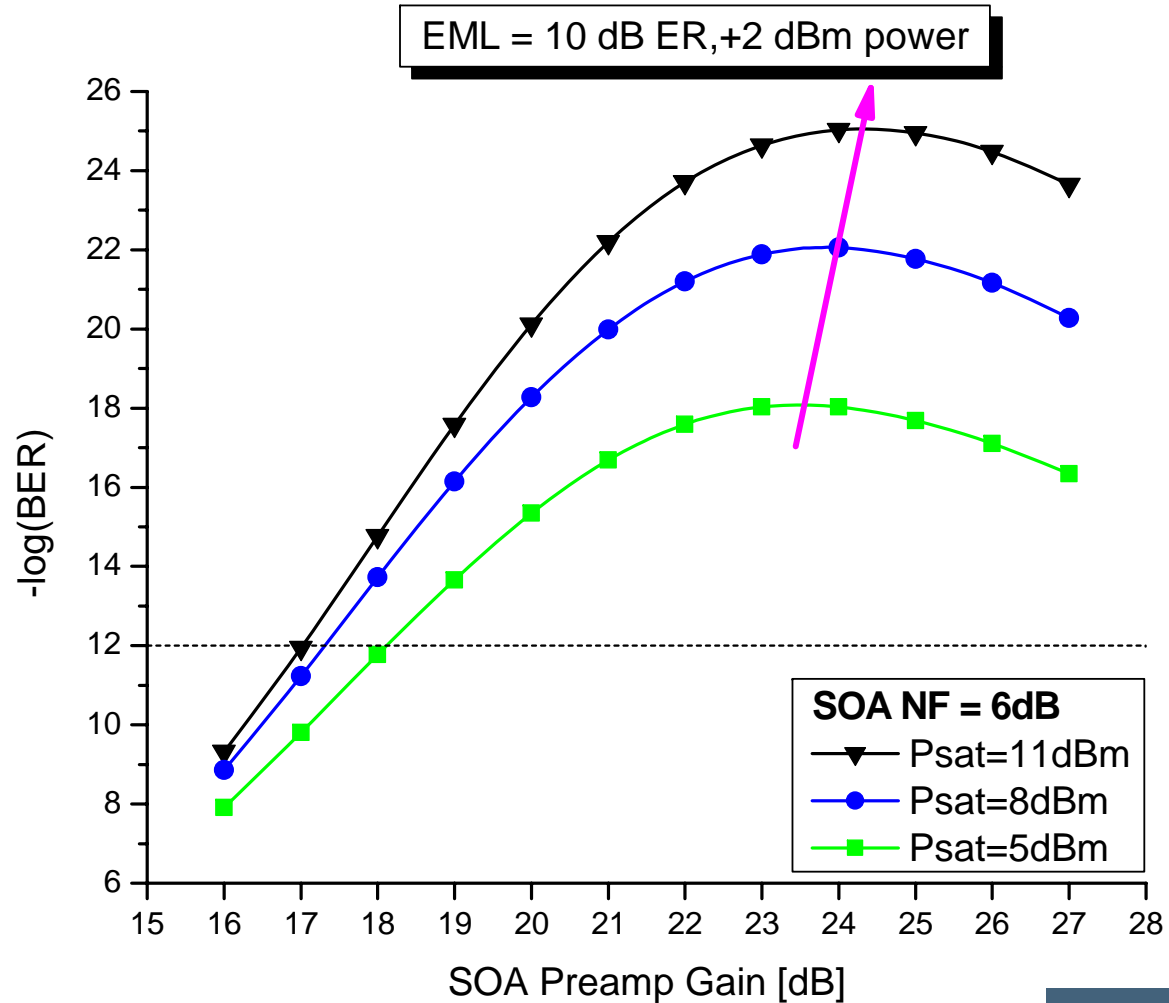
Total Power @ OFE (NF=9dB)



40-km link (22 dB loss)



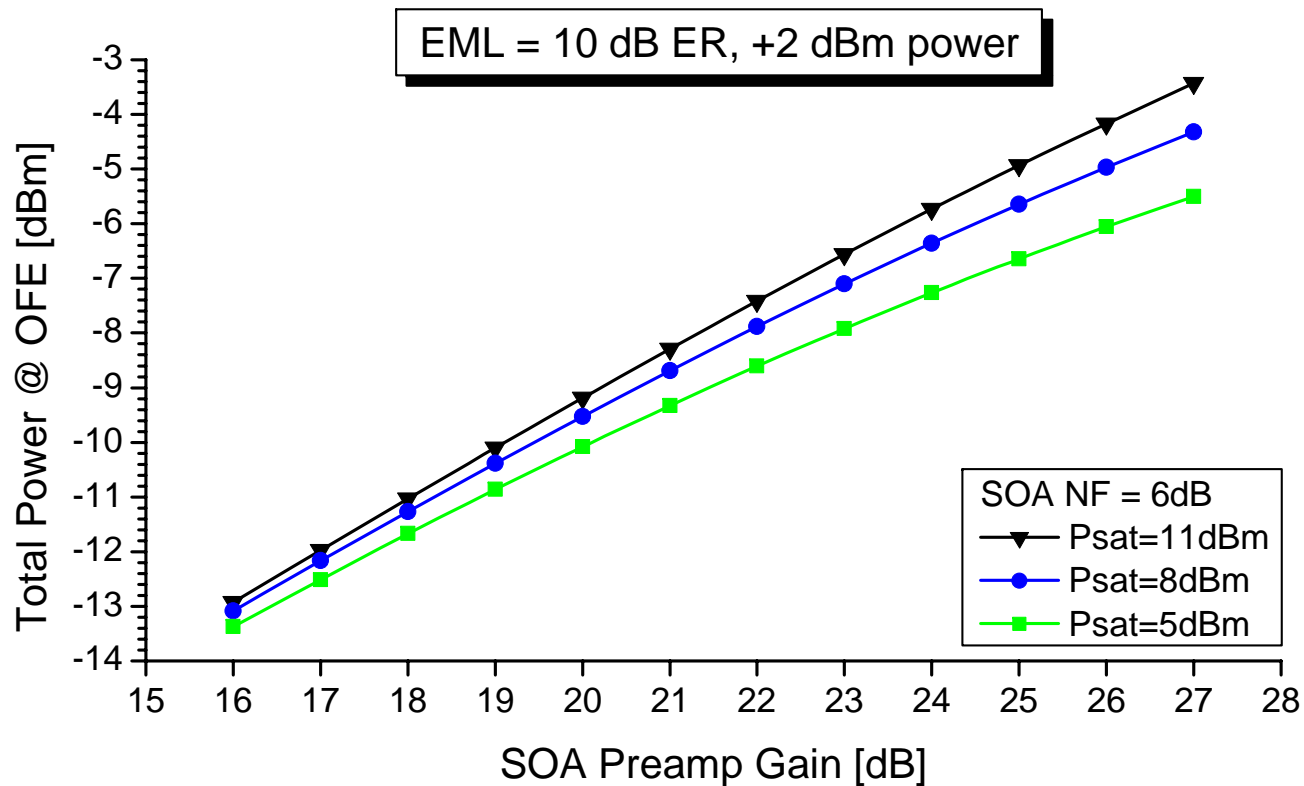
BER Performance (NF=6dB)



40-km link (22 dB loss)



Total Power @ OFE (NF=6dB)



40-km link (22 dB loss)