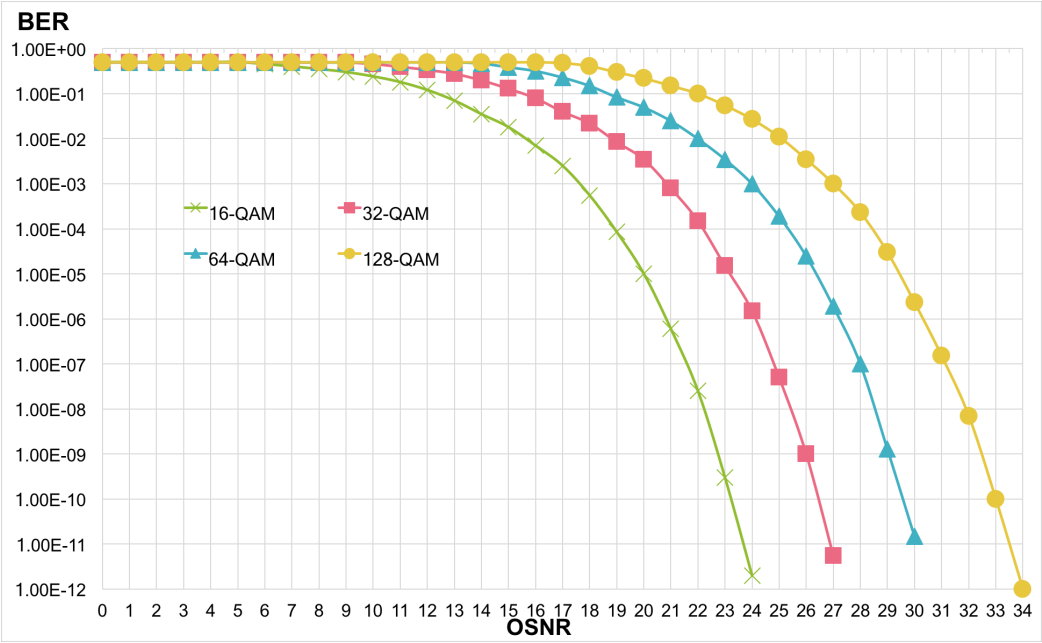
Tutorial 10, CS1031

1. Long length optical link design

An optical transmission link operates at a BER of 10^{-6} and the transmitter maximum symbol rate is 10GBaud.

a) Referring to the SNR/BER figure below, calculate the maximum bit rate achievable over a link length of 100 km, if the fibre loss is 0.25 dB/km, the receiver sensitivity is –23 dBm, and the launch power is 4 mW. Assume a 3dB power budget margin.

b) You now need to extend the link to a total distance of 2000km. Calculate the minimum number of amplifiers and/or regenerators needed to achieve the same bit rate as the system designed in the exercise a) above. Assume the amplifier NF is 7 dB, the maximum gain is 25 dB, the minimum amplifier spacing possible is 50 km and the OSNR margin required is 2 dB.



a) For this case the system is power limited rather than OSNR limited, so we only need to check whether the

power is higher than the receiver sensitivity at the end.

P_recv= P_launch - loss - power_margin > sensitivity.

The power needs to be converted into dB, so 4 mW = 1*2*2 = 0+3+3 = 6 dB.

The loss is 0.25 * 100 = 25 dB

P_recv=6 - 25 - 3 = -22 > -23 so the transmission will work.

Since the SNR is not an issue the highest bit rate can be achieved, of 10 x log2(128) = 70Gb/s

b) Because the distance is too long, amplifiers need to be added.

The system is likely OSNR limited so the OSNR is the equation to check first.

The OSNR required, from the figure above, considering 128 QAM and BER of 10^{-6}, is 30 dB. The OSNR equation is:

$$OSNR_{recv}=P_{launch[dBm]}-\alpha_{[dB/km]}\,L_{span[km]}-NF_{ampl[dB]}-10\log_{10}(n)+58_{[dB]}-M$$

With a 80 km spacing we get

OSNR=4 - 0.25 x 80 – 7-14+58-2=19<30 so it doesn't work

If we try the minimum span of 50 km we get:

OSNR=4-12.5-7-16+58-2=24.5<30, so it won't work.

We then need to try a regenerator at half distance = 1000 km.

Trying for 50 km we get

OSNR=4-12.5-7-13+58-2=27.5<30, so it won't work.

We notice that every time we half the total dpan we gain 3 dB, so a 500 km regeneration spacing should work:

OSNR=4-12.5-7-10+58-2=30.5>30.

So we need to divide the link into 4 spans, with in total 3

regenerators and 40 amplifiers (10 per span).

For the power we just need to make sure that is above the receiver sensitivity for one span (the other spans are the same).

$$P_{recv} = P_{launch} - L_1 + G_1 - L_2 + G_2 \ldots - L_n + G_n + M > \text{receiver\_sensitivity}$$

P=4-125(total loss) + 25(gain) x 10 (amplifiers) -3 (margin) = 4-125+250-3=126 >>-23

So this equation is also satisfied.