Tutorial 9, CS1031

1. Optical link design

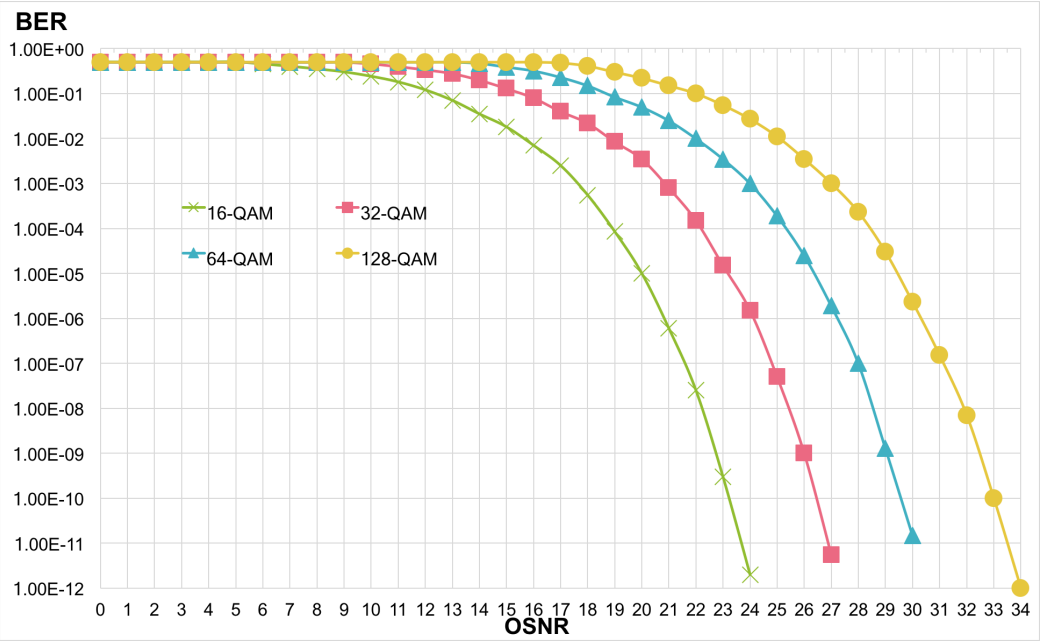
You need to operate a transmission link working at 12 Gb/s, over fibre. Your transmitter maximum rate is 2 Gbaud, and you want your system to achieve a BER of 10^{-9}.

The total link length is 80km, the fibre loss is 0.25 dB/km. The receiver sensitivity is –27 dBm, and the launch power is 8 mW.

a. Calculate whether the system will work without amplifiers, considering a power budget margin of 2 dB.

b. You need to extend the system to work up to a distance of 250km, and you can use only one amplifier, which has a noise figure of 6 dB and a gain of 30dB. Calculate whether the transmission can occur at 12 Gb/s with BER of 10^{-9}, considering an OSNR margin of 3 dB.

If not, calculate whether the system can work at a lower rate, stating the maximum rate achievable.



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 8 mW = 1*2*2*2 = 0+3+3+3 = 9 dB.

The loss is 0.25 * 80 = 20 dB

P_recv=9 - 20 - 2 = -13 > -27 so the transmission will work.

b) for 250 km the loss is 62.25 dB, so the system cannot work without an amplifier.

Since we now add an amplifier, which will add noise, the system could be OSNR limited, so we also need to check the OSNR equation.

We first check if the total power is enough:

P_recv=P_launch-loss+gain_ampl-power_margin =

= 9-62.25+30-2=-25.25 > -27 so this works.

Now the OSNR:

OSNR = P_launch - Loss_span - NF_ampl + 58 - OSNR_margin

the loss of the span is the distance before reaching the amplifier. The amplifier is considered to be in the middle, so the distance is 125km and the loss = 0.25 * 125 = 31.25 dB.

OSNR = 9-31.25-6+58-3=26.75

This now needs to be checked against the OSNR_threshold, from the graph.

In order to achieve a bit rate of 12Gb/s with a 2 Gbaud transceiver, we need a 64-QAM modulation (which encodes 6 bits per symbol). From the plot, achieving a BER of 10^{-9} with a 64-QAM requires 29 dB of OSNR, which is not available in the system. So 12 Gb/s

cannot be achieved.

However the 32-QAM modulation requires an OSNR 26 dB to work at BER of 10^{-9}, which is achievable by the system. Since the 32-QAM encodes 5 bits per symbol, the maximum rate is 2Gbaud x 5 = 10 Gb/s.