ONS Problem Set 4

Wednesday, December 14, 2016

Problem 1: Concatenation of amplifiers

Consider a fiber link of in total 300 km. Compare the link in terms of its noise figure if it is sub-divided into

a) three equally distributed spans, i.e. an amplifier spacing of 100 km each,
b) three spans with respective lengths of L_1 = 140 km, $L_2 = L_3$ = 80 km,
c) three spans with $L_1 = L_2$ = 80 km, L_3 = 140 km
d) four spans, each 75 km long.

Assume that each amplifier compensates the loss of the preceding fiber span and that the noise figure of all amplifiers is F = 6. Calculate the OSNR at the receiver if the launch power is 1 mW.

Problem 2: PON Design

a) For a passive optical network (PON) system, the launch power is 0 dBm and the required power at the receiver for an error-free signal performance is -21 dBm. Calculate the maximum number of users that can be supplied by this system over a maximum reach of 50 km.
b) The system is to be extended to 64 users and a longer reach. Therefore, a booster optical amplifier (BOA), with an output power of 10 dBm is added at the optical line terminal (OLT). Additionally, each optical network unit (ONU) is equipped with an additional optical pre amplifier. The noise figures are given as F_{BOA} = 5 dB and F_{pre} = 3 dB. Calculate the maximum reach, if an OSNR of 17 dB is required at the receiver, i.e behind the optical pre-amplifier.

Problem 3: Mach-Zehnder Modulator

Derive the (complex) amplitude transfer function of a Mach-Zehnder modulator (MZM) for the general case, i.e. for independent drive signals for the two modulator-arms. From this result, derive the simplified transfer functions for push-pull and push-push operation. Explain where the optical power is dissipated if the modulator is operated in its null point. Therefore consider an MZM with two output ports.

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