ONS Problem Set 6

Wednesday, January 10, 2018

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: Wavelength-division multiplexing (WDM)

a) What is WDM?
b) What is an optical frequency grid? Assuming a 100 GHz grid standard (ITU-T G.694.1), what would be the benefit of switching from a 10 Gbit/s data signal to a 40 Gbit/s data signal in each grid?

Problem 3: Polarization-Mode Dispersion (PMD)

a) What is PMD? Do you expect PMD in an ideal single-mode fiber?
b) Assume an optical pulse is incident into a fiber as shown in Fig.1. We assume a non-ideal fiber such that refractive index $n_x > n_y$ leading to a differential group delay $\Delta\tau$. Depict what the signal looks like at the output of the fiber.

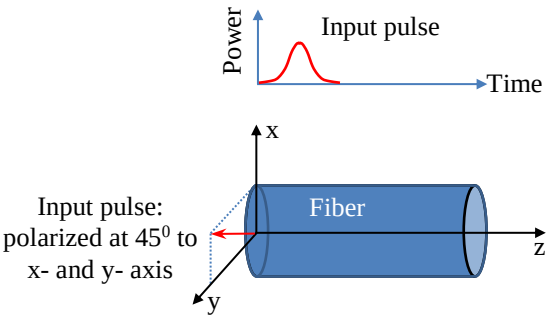

Figure 1. The impact of fiber birefringence on the pulse shape which has equal x- and y- polarization components.

c) Assume you can tolerate a mean differential group delay $\langle\Delta\tau_{link}\rangle$ that is 10 % the symbol period of your signal. Complete Table 1 using the parameters given.

Table 1. Transmission reach with different fibers and data rates

Data rate (Gbit/s)	$\langle\Delta\tau_{link}\rangle$ (ps)	L_{link} (km) [for old legacy fiber with D_{PMD} = 0.5 ps/√km]	L_{link} (km) [for newer fiber with D_{PMD} = 0.02 ps/√km]
10			
40			

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