ONS Problem Set 1

Wednesday, November 2, 2016

Problem 1: Power Budget

Assume an optical point-to-point link operating at 10 Gbit/s on-off-keying (OOK) and at wavelengths λ_1 = 1300 nm and λ_2 = 1550 nm. At the transmitter (Tx), 1 dBm of optical power is launched into an optical standard single-mode fiber (SSMF). The required power at the receiver for a given bit error ratio (BER) of 10^{-9} is 10 µW.

a) Determine the power density in the fiber core when assuming a homogeneous power distribution that is entirely confined to the fiber core.
Note that a homogeneous distribution is not a realistic scenario!

b) Calculate the maximum reach of an unamplified fiber link for the two operating wavelengths. Extract the fiber loss coefficient from the Fig. 1.

c) Fig. 2 shows the responsivity of photodiodes in different material platforms. We find that the responsivity is increasing with wavelength and then strongly dropping. Explain this behavior.

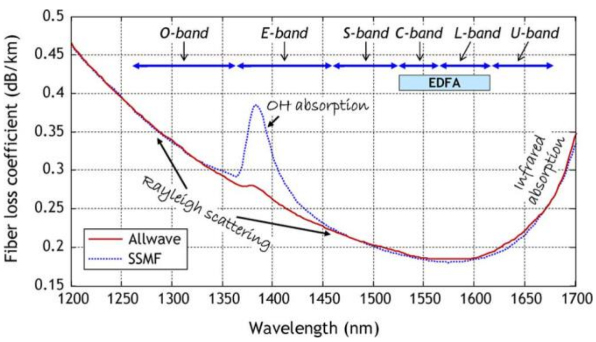

Figure 1: Typical loss of an optical fiber

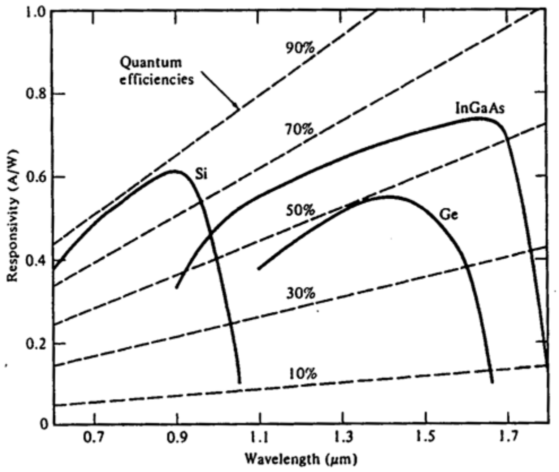

Figure 2: Responsivity of photodiodes in various material platforms

Problem 2: Bit error ratio (BER)

a) Derive the optimum threshold for the decision threshold for an OOK signal.

b) Calculate the BER if the signal power of a 10 Gbit/s OOK data signal at the receiver is -19 dBm and -23 dBm, respectively. The noise equivalent power (NEP) is $9\,\mathrm{pW}/\sqrt{\mathrm{Hz}}$.

c) Derive a term for the BER of a 4-level pulse amplitude modulation (PAM4) signal.

Problem 3: Transmitter & Receiver Filters, Matched Filter

a) Describe a transmission system mathematically using a transmitter filter $p(t)$ and receiver filter $q(t)$.

b) From the equation derived in part a), calculate the signal-to-noise ratio (SNR) and show that a matched filter maximizes the SNR.

c) Give the units of the time signals and the filter impulse responses.

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