ONS Problem Set 1

Wednesday, October 25, 2017

Problem 1: Optical Fiber

An optical fiber transports signals that are at optical frequencies between two points.

a) Plot a schematic depicting the basic structure of an optical fiber and indicate the parts.
b) What is a weekly guiding fiber? How is an optical wave approximated in such a fiber?

Problem 2: Working with Decibel (dB): Power Budget

Note: When comparing two power values P_1 and P_2, the ratio P_1/P_2 of the powers can be expressed in decibel (dB) as $10log_{10}(P_1/P_2)$. Using a reference power of 1 mW for P_2, the absolute power P_1 can also be expressed in decibel as $10log_{10}(P_1[\text{in mW}]/1\text{ mW})$ with the unit dBm.

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, Core diameter = 8 µm). 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 (at the input end) 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 Fig. 1.

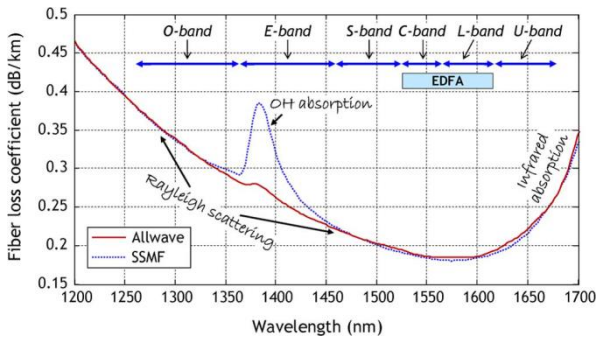

Figure 1: Typical loss of an optical fiber

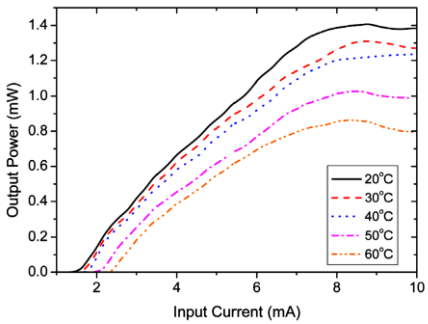

Figure 2: Measured PI curve of a VCSEL
Adapted from: C. Park et al., "Evaluation of 1.3 um wavelength VCSELs grown by metal organic vapor deposition for 10 Gb/s fiber transmission," JSOK, vol. 16(3), 2012.

Problem 3: Intensity Modulation (IM)

There are different mechanisms to encode information signal on an optical carrier. Intensity modulation is by far the simplest and commonly used method.

a) Mention two light sources that can be used with intensity modulation.
b) The measured PI curve of a laser is given in Fig. 2. Where would you set the bias current for intensity modulation? Assume zero mean drive voltage.
c) Assume a two level modulation. What is the optical modulation amplitude (OMA) obtained for the different operating temperature of the laser when using modulating current levels that are 2 mA above and below the bias current in (b)?
   Definition: OMA = P_{max} - P_{min}
d) Now, assume a four level modulation signal and 2 mA spacing between each drive level. Plot the resulting intensity curve at 60 °C operation. What do you observe?

Juned N. Kemal, Bldg. 30.10, Room 2.33,
E-Mail: juned.kemal@kit.edu
Mosaddek Hossaine Adib, Bldg. 30.10