Course of Optical Communications – Telecommunication Engineering

Prof. Maria-Gabriella Di Benedetto

Practice Work n°3 – 10/05/2006

Last Name:_______________________ First Name: ______________________

PROBLEMS

3.1 An InGaAsP LED emits at 1310 nm. The drive current is 40 mA. If the internal quantum efficiency is 77%, calculate the internal optical power level.

3.2 The external quantum efficiency typically depends upon the refraction index of the material. A standard expression is $\eta_{ext} = \dfrac{1}{n(n+1)^2}$. Calculate the external quantum efficiency for a LED.

a) with a typical refractive index value n=3.5.

b) with a typical refractive index value n=2.7.

3.3 How many photons per second correspond to a light emitted in the third window with power P = 1 W?

3.4 The optical power generated inside a LED is 28.4 mW with a 60 mA current.

a) What is the emission wavelength if the internal quantum efficiency is 50 %?

b) If the optical power emitted is 0.284 mW, what is the external quantum efficiency η_e? And the overall efficiency η?

c) In case the external quantum efficiency was 5 %, what would be the optical power?

3.5 A laser pointer produces a beam with power $P = 2$ mW. The beam enters the eye and is focused by the cornea and lens to a spot on the retina with diameter $D = 16$ μm. What is the irradiance of the focused laser pointer beam on the retina?

3.6 Calculate the transmission frequency and the photon energy of each of the following optical sources (assume free-space propagation):

a) He-Ne laser, $\lambda = 0.6328\mu m$

b) Nd^{3+} laser, $\lambda = 1.059\mu m$

c) CO_2 laser, $\lambda = 10.6\mu m$

3.7 Calculate the spread of frequencies Δf between the half-power points of the following optical sources:

a) A GaAlAs laser with a spectral half-width of 3nm around a peak power wavelength of 0.82μm.

b) An InGaAsP/InP light emitting diode source having a spectral half-width of 110nm around a peak power wavelength of 1.55μm.

Note: $\gamma = |\Delta\lambda/\lambda| = |\Delta f/f|$

3.8 Consider the optical emitter of Figure 1, based on a Light Emitting Diode (LED).

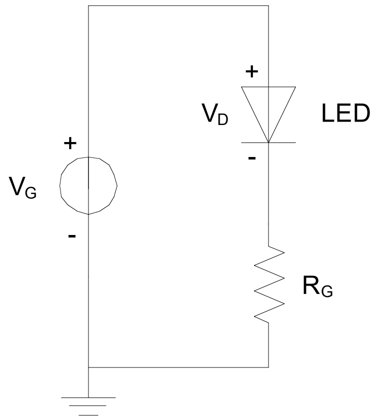

Figure 1 – Optical emitter

The emitter is powered by an electrical driver formed of an ideal voltage generator, providing a voltage $V_G = 12$ V, and having a resistance R_G. During standard operation, the voltage at the poles of the LED is $V_D = 2$ V.

a) Determine the value of resistance R_G that guarantees a driving current $I_D = 100$ mA;
b) Knowing that at T = 298 K the spectral width at half power of the light emitted by the LED is 45 nm, and assuming that the spectrum width increases as a function of temperature by 0.3 nm/K, determine the temperature T' at which the spectral width reaches 75 nm. Is T' an acceptable operating temperature for a commercial LED?

Let us consider now a different emitter, where a LASER is used in place of the above LED. The LASER emits at λ = 1550 nm and is characterized by a threshold current I_t that varies with temperature according to the following relation:

$$I_t(T) = I_t(T_l) \cdot e^{\frac{T - T_l}{T_0}}$$, with $T_0 = 150$ K

For $T = T_l = 298$ K, the LASER is characterized by $I_t = 20$ mA.

c) Assuming $T = T_l$, determine the maximum value for R_G leading to $I_D \geq I_t$.
d) Recalculate the maximum R_G required to keep $I_D \geq I_t$ if $T = 373$ K.
e) What happens if condition $I_D \geq I_t$ is not met (Choose one of the following)?
   a. The LASER does not generate any optical power
   b. The LASER behaves like a LED
   c. The LASER gets damaged
f) For the value of R_G determined at point d), determine if an output optical power $P_{OUT} = 35$ mW can be achieved under ideal conditions.
g) Determine the value of R_G required to obtain an output optical power $P_{OUT} = 40$ mW if the LASER is characterized by η_i=0.75, η_e=0.9.