Exam
“Basics of Opto-Electronics”

21/02/2022

INSTRUCTIONS (PLEASE READ BEFORE STARTING)

Please answer in a separate paper sheet and try to write as readable as possible.
Identify properly each piece of paper with your answers and number them.
Clearly highlight your answers and in case of mistake please make sure the wrong answer is properly crossed.
Once you have finished, please double check that you have been through all the questions.
Calculators are allowed.
Formulas are provided at the end of the questionnaire.
No extra formulas sheet is allowed.

Useful relations:

$h = 6.626\times10^{-34}$ J·s,
$k_B = 1.381\times10^{-23}$J/K,
temperature in Kelvin=Celcius+273.15,
$q = 1.602 \times 10^{-19}$ C,
c = 299 792 458 m/s,
and $W = A^2\Omega$.

Exercise 1

Consider the following heterojunction pin photodiode.

Considering a declared Responsivity of 0.95 A/W at 1550 nm and a NEP of $2.66e^{-15}$ and a dark current of 4 nA.

1. Calculate the external quantum efficiency of the detector
2. Considering a bandwidth of 10 GHz what is the minimum power P1 required for an SNR of 1?
3. What is the minimum detectable optical power corresponding to the dark current?
4. Considering a load resistance of 500 ohms what is the corresponding noise current at 300K. What are your conclusions

Exercise 2

A communication system uses the previous receiver at 1550 nm with a data rate of 2.5 GB/s.
The transmitter has a spectral linewidth of 0.2 nm.

1. Calculate the SNR for an incoming power of 1uW
2. Considering that the receiver is connected to a fiber with loss of 0.2 dB/km what is the length of the fiber knowing that the input power is 1 mW?
3. If the fiber has dispersion of -18ps/nm.km, will the system work?
4. If no, can you comment on how to achieve that?

5. What is the minimum length of a possible compensating fiber with a dispersion 100ps/nm.km?
6. Repeat the reasoning of a data rate of 10 GB/s and a laser linewidth of 0.02 nm.

Exercise 3

An optical fiber has a core diameter of 8.2 um and refractive index difference of 0.36% and a core index of 1.4682.

1. What is the V parameter at 1.31 um and 1.55 um?
2. What is the minimum wavelength to get a single mode propagation?
3. What is the numerical aperture and the angle of acceptance of the fiber?
4. What are the different types of dispersion in an optical fiber

Exercise 4

A laser diode operates at 850 nm and has a spectral width of 250 GHz, a cavity length of 500 um and a refractive index of 3.2.

1. What is the corresponding spectral width in wavelength?
2. What is the mode spacing?
3. What is the reflection of the mirrors (considering the same reflection on both facets) of the cavity to get this spectral width?
4. How could you obtain this reflectivity?
5. Making the approximation that the output of the laser is a gaussian beam and a divergence angle 2θ of 30° what is the beam waist?
6. Considering an optical fiber with a mode field diameter of 9um what is the maximum distance at which the fiber can be put to avoid loosing optical power?