Course of Optical Communications – Telecommunication Engineering

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Practice Work n°4 – 11/05/2006

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PROBLEMS

4.1 When $3x10^{11}$ photons emitted at a wavelength $\lambda = 0.85\ \mu m$ hit a PIN photodiode, the terminals of the device get $1.2x10^{11}$ electrons. What is the quantum efficiency and the responsivity of the photodiode at this wavelength?

4.2 A PIN photodiode with quantum efficiency $\eta=0.7$ receives an optical power $P_{in}=1.5\mu W$. Find:

a) The responsivity of the photodiode for a $1.34\mu m$ wavelength.

b) The generated photocurrent.

4.3 The quantum efficiency of a APD Si diode is $\eta = 0.8$ for the detection of the optic radiation of $\lambda = 0.9\ \mu m$ wavelength. The APD is such that for an incident optical power $P_{OPT} = 0.5\ \mu W$, an output current $I_P = 11\ \mu A$ is generated. Determine the gain M introduced by the photo-multiplication effect.

4.4 A photodiode has a quantum efficiency of 0.65 when it receives photons of energy $E = 1.5x10^{-19}$ J. What is the working wavelength of the photodiode? What is the incident optical power P_{OPT} needed to generate a photocurrent $I_P = 2.5\ \mu A$?

4.5 A PIN photodiode generates 1 electron for every 3 incident photons at wavelength $\lambda = 0.8\ \mu m$. Find:

a) The quantum efficiency of the photodiode.

b)The maximum suitable bandgap energy.

c) The photocurrent when the optical power is 10^{-7} W.

4.6 What is the wavelength to make the quantum efficiency equal to the responsivity?

4.7 The quantum efficiency of a APD photodiode is 70% in the second window. When the incident optical power is $0.25\ \mu W$ the photocurrent is $10\ \mu A$. What is the multiplication gain of the photodiode?

4.8 At the output of an optical receiver with a bandwidth B=1 GHz a photocurrent of 0.1 mA is detected. What is the shot noise current if the dark current is $0.1\ \mu A$?

4.9 Consider the optical receiver in Figure 1.

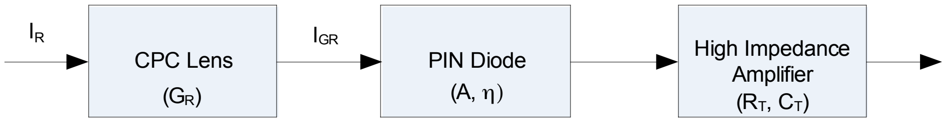

Figure 1. Optical receiver

The light arriving at the input of the CPC concentrator is characterized by a wavelength $\lambda = 1550$ nm, and by an irradiance $I_R = 0.3$ mW/m^2. The CPC concentrator provides an optical gain that can be assumed constant and equal to $G_T = 10$ dB. The receiver has an active area $A = 3$ cm^2 and a quantum efficiency η=0.75. Assume that a PIN photodiode is used.

a) Determine the generated photocurrent I_P at the output of the receiver.

The photodiode is coupled to a high impedance front-end, characterized by a capacitance $C_T = 5$ pF and a noise figure F = 10 dB. The amplifier introduces a cut-off frequency f_{3dB} equal to 0.75 of the signal bandwidth B, with B = 70 MHz.

b) Determine the value of the input resistance of the amplifier R_T.
c) Determine the Signal to Thermal Noise Ratio SNR_J.
d) Determine the Signal to Shot Noise Ratio SNR_{Sh}.

Assuming now that the PIN photodiode is replaced by an APD diode with gain M and a=1,

e) Determine the value of M that leads to $SNR_J = SNR_{Sh}$.
f) For the value of M determined at e), and in absence of incident light, determine the NEP of the receiver, assuming that the dark current is $I_d = 3$ nA.