Course of Optical Communications – Telecommunication Engineering

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Practice Work n°5 – 23/05/2006

Last Name:____________________ **First Name:** ____________________

PROBLEMS

5.1 Let us consider four optical communication systems using LASERS at frequencies: f_1=2.5x10^{14}Hz, f_2=3.75x10^{14}Hz, f_3=5.0x10^{14}Hz and f_4=6x10^{14}Hz. Determine:

a) which of the four systems is more affected by sunlight interference

b) which of the four systems is more affected by incandescent interference

c) which of the four systems is more affected by fluorescent interference

5.2 What source of environmental noise will you have most to take care if you are working with an Infrared LED?

5.3 Consider a satellite communicating to another satellite at a 555nm wavelength. What would the spectral irradiance of the solar radiation noise be? And what if the satellite is communicating with the receiver of a ship?

5.4 If we have an emitter on a ground laboratory that emits with a 555nm LASER towards a receiver sensible to the range of wavelengths $\Delta\lambda$ = [300, 900] nm and with an active area of radius R=1 cm, what will be the radiant flux due to sunlight?

5.5 We have an optical communication system with a LASER emitting to a receiver PIN diode characterized by a bandwidth B of 50 MHz. The generated photocurrent I_P is 1 μA. The amplifier connected to the output of the PIN diode is characterized by an input resistance R_L = 50 Ohm and a noise factor F = 3 dB, introducing a noise characterized as a current I_J.

a) If the only ambient noise is the direct sun, and we do not have any filter, what is the signal to *total* noise ratio at the output of the photodiode?

b) What is the signal to *shot* noise ratio at the output of the photodiode?

c) What is the signal to *shot* noise ratio at the output of the photodiode if an optical filter is adopted?

5.6 Consider the same communication system as in exercise number 5, but in this case with ambient noise formed of a fluorescent light, without optical filters.

a) What is the signal to *shot* noise ratio at the output of the photodiode?

b) What is the signal to *total* noise ratio at the output of the photodiode?

c) What is the signal to *total* noise ratio at the output of the photodiode in presence of an optical filter?

5.7 For indoor applications, what kind of noise is more relevant if we are transmitting at 9 Mb/s? What is the maximum bit rate for which noise components can be reduced to shot noise at the receiver? What is the input-referred noise variance at this bit rate?

5.8 A 2.5Gb/s NRZ signal (λ=1.55μm) is received by making use of a PIN diode. The receiver has an equivalent noise current I_{ENC} = 0.3163 pA/$Hz^{1/2}$ and a bandwidth of 2 GHz.

a) Calculate the minimum input power for obtaining a BER of 10^{-9} in case the quantum efficiency of the detector is 100%.

Note: BER=10^{-9} → SNR(dB)=21.58dB

b)What would it change if the quantum efficiency of the detector was 50%?

5.9 A receiver with a 3dB bandwidth of 0.5 GHz and an equivalent spectral noise I_N^2=5x10^{-24} A^2/Hz is used on a 120 km fiber link with a 0.3 dB/km attenuation. The transmitter produces 1 mW in the fiber at a λ=1.3 μm wavelength. Estimate the SNR at the receiver if the receiver is a PIN photodetector with a responsivity ρ = 1 A/W.

5.10 We have an optical communication system with a LASER emitting to an APD receiver characterized by a bandwidth B = 50 MHz, a gain M = 25 and an excess factor F_e = 5. The output photocurrent $M \cdot I_P$ is 25 μA. The amplifier connected to the output of the APD is characterized by an input resistance R_L = 50 Ohm and a noise factor F = 3 dB, introducing a noise characterized as a current I_J.

a) If the only ambient noise is the direct sun, and we do not have any filter, what is the signal to *total* noise ratio at the output of the APD?

b) What is the signal to *shot* noise ratio at the output of the APD?

c) What is the signal to *shot* noise ratio at the output of the APD if an optical filter is adopted?

d) Compare the results obtained in the case of an APD with those obtained with a PIN diode (Problem 5.5). Which of the two receivers is more sensible to interference? And why?