OC Problem Set 8

Friday, June 19, 2015

Problem 1: Equivalent circuit for noisy components

Explain the various noise sources for optical detection and determine the equivalent circuit using noise-free components.

Problem 2: Responsivity of a photodiode and noise properties

- A photodiode has a responsivity of $S = 0.5$ A/W. It is illuminated with a power of −30 dBm. Which current is flowing?
- Which optical power P_e is required for shot noise limited detection with a photodiode at room temperature $T = 293$K, an electronic amplifier admittance $G = 1/50\Omega$ and electronic amplifier noise figure $F = 5$dB (compare Fig. 7.1 in the script). What is the limiting noise mechanism if desired power levels at the receiver are as low as −35 dBm?

Problem 3: *Q*-Factor, SNR and BER in direct detection systems

a) Briefly describe the meaning of Eq. (7.6) in connection with Eq. (7.5). Draw the probability density functions (pdf) for the voltages in front of the decider at the sampling point of time for a transmitted 1 and also for a transmitted 0. Which assumptions are required that this description is applicable?

b) Show that for the Gaussian pdf

$$w(z) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{(z-A)^2}{2\sigma^2} \right],$$

the following relation is applicable

$$\int_{z_1}^{z_2} w(z)dz = \frac{1}{2}\operatorname{erf}\left(\frac{z-A}{\sigma\sqrt{2}} \right)\Bigg|_{z_1}^{z_2} = \frac{1}{2}\operatorname{erfc}\left(\frac{z-A}{\sigma\sqrt{2}} \right)\Bigg|_{z_2}^{z_1},$$

with the definitions of the error function and the complementary error function

$$\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x \exp(-t^2)dt,$$

$$\operatorname{erfc}(x) = 1 - \operatorname{erf}(x).$$

c) Calculate the probability of deciding 1 when 0 is received and vice versa.

d) Calculate a relation to determine the optimum decision threshold u_S.
(Write down only the formulae, but do not solve the equation for u_S).

e) Assume that $\sigma_0 w(1r) = \sigma_1 w(0r)$. Calculate the optimum threshold and the corresponding minimum bit error ratio (BER).
Help: Use the Q-factor definition, which has been introduced in Eq. (7.14).

f) How is the signal-to-noise-ratio (SNR) related to the Q factor (from (e))?

g) What are the assumptions required to express the BER by the SNR? Calculate the required SNR for a BER of 10^{-9}.

h) Assume shot noise limited reception for OOK signals and Poisson distribution of photons (compare Eq. (6.6)). Calculate the average number of bits for a BER < 10^{-9}.

For questions and suggestions on the OC tutorial please contact:

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