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EECS 118: Optical Communication Systems

Problem Set No. 3 : Probability, Channel Capacity, and S/N ratio Calculations

Problem 1) Channel Capacity
Consider a CD recording. Assume a speed of 7500 rpm and a typical radius of 10 cm. Assume the spot size of the storage pits is 2 μ m .
a) What is the maximum number of bits which can be stored (for binary storage)?
b) For the rpm of 7500, what is the maximum read bit rate?
c) If a signal to noise ratio of 35 dB is to be guaranteed, what sampling band-width can be used?
d) For binary transmission, what channel bandwidth is needed? How can this be reduced?
e) How many bits per sample are there?
f) If the area of the laser beam focussed on the spots is 1mm, what focal length lens is needed?
g) What is the advantage of a blue laser in contrast to a red one? How else might the storage capacity and bit rates be increased?

Problem 2) Probability
a) Starting with a signal $f(t,z)) = sin(\omega t - kz + \Delta\phi)$, show that if $\Delta\phi$ is a Gaussian random variable with a mean-square deviation given by constant, σ^2 multiplied by t , then f(t) when average decreases exponentially with time. (Take z = 0).
b) Show that in the limit as the average of a Poisson distribution becomes large, it goes over to a Gaussian distribution with a standard deviation equal to that of the Poisson.

Problem 3) Receiver Sensitivity Calculation
A PCM receiver must have a signal to noise ratio of at least 20 dB to function with an adequate probability of error. The receiver uses a PIN diode with a responsivity of .7 amps/Watt. The rms noise in the receiver is 7 μ Volts, due primarily to thermal noise; the shot noise and amplifier noise are negligible.
a) What is the sensitivity of the receiver?

Problem 4) APD Noise Calculation
An optical receiver uses a detector with a current gain G_m of 50 and an excess noise factor F_A of 5 . The responsivity $\mathcal{R}$ is .7 amps per watt. The photodetector load impedance consists of R = 800 Ω and C = .10 pF in parallel. The noise of the amplifier following can be included as a noise voltage in series with the amplifier input (which has an infinite input resistance). The amplifier has a bandwidth of 1 GHz.
a) Calculate the total rms noise voltage referred to the input of the amplifier when the optical power is 0.1 μ W .
b) What is the signal to noise ratio?