University of California
College of Engineering
Department of Electrical Engineering
and Computer Sciences

EECS 118 T. K. Gustafson
3 units
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Optical Communications Systems

Instructor: T.K. Gustafson 459 Cory, 2-3139, Office Hrs: M 1-2, Tu 9:30-11:30, Th 10-12

Problem Set Four: Receiver, Optical Amplification, and Coherent Detection

1) **Basic Receiver Problem**
Estimate the required average incident optical power at a receiver in order to assure an error rate of $1 \cdot 10^{-10}$. The system components have the following characteristics and operating conditions:

p-i-n photodiode quantum efficiency	60%
effective load impedance of the diode	5kΩ
preamplifier noise figure	4 dB
operating wavelength	1.3 μm
operating temperature	300 K
receiver post detection bandwidth	10 GHz
load capacitance	100fF

2) **Optical Amplification**
a) An optical amplifier can amplify a 10μW signal to the 1 mW level. What is the output power when a 1 mW signal is incident if the saturation power is 10 mW.
b) Deduce the SNR for an ideal amplifier incuding both signal shot noise and the signal-spontaneous beat noise. Show that the minimum noise figure is 3 dB. (i.e. that the noise factor is at best 2).
c) The optical amplifier is used in the link of problem 1 before the detector. For the same source power calculate the new B.E.R. Assume an optical bandwidth limited to the electrical bandwidth by a filter, and a spontaneous emission factor of .5.

3) **Coherent Detection**
Show that the quantum-limited sensitivity for a heterodyne FSK detection scheme is 36 photons per bit.