EE472 Chapter 7 Homework

1. A certain digital fiber optic communication link operates at 850 nm. The laser diode at the source turns completely off when a zero is transmitted. The receiver operates at 300 EK with a quantum efficiency of η = 0.85 and has an equivalent load resistance of R = 100 Ω. The receiver bandwidth is 500 MHz, and it is dominated by thermal noise. a) What is the optical power required in a digital one to insure a Q of 8? b) What is the BER with this power? c) If the laser diode at the source is then biased above threshold with an extinction ratio $e = 10\log(P_{IN0} / P_{IN1})$ = -6 dB, how much does the BER increase?

Ans: a) 7.9μW; b) 10^{-15}; c) 10^{-9}

2. Given $Q = \frac{I_{th} - I_0}{s_0} = \frac{I_1 - I_{th}}{s_1}$, show that $Q = \frac{I_1 - I_0}{s_1 + s_0}$ and that $I_{th} = \frac{s_0 I_1 + s_1 I_0}{s_1 + s_0}$.

3. A certain high-speed digital fiber link uses the SONET OC-48 bit rate of BR = 2.5 Gb/s. The **average** power at the source is 55 μW, and the extinction ratio is $e = 10\log(P_{IN0} / P_{IN1})$ = -10 dB. Fiber loss is 0.35 dB/km at the source wavelength of 1.3 μm. The receiver operates at room temperature and uses a transimpedance amplifier with an open-loop gain of A = 10^3, a feedback resistance of R_L = 1 kΩ and a diode capacitance of 100 pF.

a) Solve for the receiver bandwidth B and the launched powers, P_{IN0} and P_{IN1}.

b) A detector made out of InGaAs has the best quantum efficiency at 1.3 μm. Calculate the responsivity if η = 0.6 in the detector.

c) Predict the maximum attenuation-limited length of the link if a BER < 10^{-9} is required in the receiver? This requires $Q \geq 6$. (This is challenging: First assume that thermal noise dominates. Then solve for P_1 at the receiver and compare it to P_{IN1} at the source.)

d) D = 1 ps/nm-km at 1.3 μm and the linewidth of the source is $\delta\lambda$ = 3 nm. If the condition to prevent excessive ISI (intersymbol interference) is $4 \cdot BR \cdot dt < 1$, where dt is the dispersive spread in the pulse, what is the dispersion-limited length of the link? Is the link dispersion-limited or loss-limited?

e) What happens if a high-impedance amplifier is used instead (with the same resistance and capacitance values)?

Ans: a) 2.5GHz, 10μW, 100μW; b) 0.63A/W; c) 39.2km; d) 33.3km; e) B = 2.5MHz, too low to be of any use at this data rate