University of California, Santa Barbara Spring 2011
Department of ECE

ECE228B
Fiber Optic Components and Systems
Homework #2

Problem 1:

Consider a 1.55 μm InGaAsP /InP bulk laser 400 μm in length with confinement factor Γ=.05, internal quantum efficiency of 80% and internal loss of 10 cm-1. cleaved facets, 0.2 mm thick active region, 0.1 ps lifetime for the linewidth calculation.

a. Plot the gain versus wavelength
b. Plot the peak gain versus carrier density
c. What is the mirror loss?
d. What is the threshold modal gain?
e. What is the differential quantum efficiency?
f. What is the axial mode spacing?

Problem 2:

Consider a DFB laser with a 400 μm long grating, an effective mode index 3.5 and a grating corrugation period 0.22 μm. Calculate the symmetric modes (wavelengths) that the laser will operate at assuming no λ/4 phase shift in the grating. What will be the output wavelength if the grating is fabricated with a λ/4 phase shift in the grating?

Problem 3:

Consider a ridge waveguide bulk InGaAsP /InP bulk laser with internal quantum efficiency of 80% and internal loss of 10 cm-1, cleaved facets, 0.2 *μ*m thick 1.55 *μ*m composition active region, differential gain 2000 cm-1 and transparency carrier density of 2.8 x 1018 cm-3. a) What is the transverse confinement factor? (use na=3.5, nc=3.17) B) How many transverse modes exist? C) Assuming the structure below with a 200 μm cavity length, calculate the lateral confinement factor and threshold current as a function of the width of the waveguide. D) For a 2 μm waveguide width, plot the threshold current versus cavity length.

Problem 4:

Calculate and plot the wavelength shift vs. tuning current for a tunable Bragg reflector that operates based on the free-carrier plasma effect. Assume λ_g = 1300nm InGaAsP tuning region operated at 1500 nm, $\beta_{pl} = -1.3 \times 10^{-20}$ cm^3, active region with L = 400μm, d = 0.3μm, w = 2 μm and confinement factor $\Gamma_t = 0.3$. For the material assume an infinite spontaneous recombination time constant, bimolecular recombination constant $B = 10^{-10}$ cm^3/s and Auger recombination constant $C = 3 \times 10^{-29}$ cm^6/s.

Problem 5:

For a mode-locked laser, assume the envelopes are given by the expression below and that the phases are equal. υ_m is the frequency spacing of mode *m*, where m=0 coincides with the central frequency of the atomic lineshape. Determine expressions for the mean power, peak power and pulse width (defined at the full-width half-maximum FWHM).

$$A_q = \sqrt{P}\,\frac{\left(\Delta\nu/2\right)^2}{\left(m\upsilon_m\right)^2 + \left(\Delta\nu/2\right)^2}\text{, m = -}\infty\text{,…,+}\infty\text{ p}$$

Term Project Part 1

This quarter you are going to simulate a complete link including the receiver. Before starting on the receiver, in Part 1, you will go back and re-design your transmitter with a new level of sophistication.

1) As with last quarter, write code to generate a Pseudo Random sequence of binary bits, this time 25 bits long.
2) Using the master rate equations for N and S, write a time domain simulation for the evolution of N and S given that your random 25 bits drive the current term in the N equation. Set your drive current so that the bias point is 1.5x the threshold of the laser and the digital modulation yields 20dB optical extinction ratio around that point.
3) Plot the time evolution of N and S over the 25 bits. Assume 100 time samples per bit. Include in your simulation the nonlinear gain compression parameter using values given in class. Also include the spontaneous emission factor term. For the recombination lifetime, use the N dependent equation with the A, B and C parameters. For all values, use those listed in the lecture notes or write your assumption.
4) From N and S, derive the equations you need to plot the amplitude, phase and frequency and then plot the time domain versions of amplitude, phase and frequency for the 25 bits.
4) Using this technique you should automatically get the attributes of bit evolution including the relaxation oscillation, damping, off level, on level,