CONTINUOUS ASSESSMENT (2023)
EE5134 OPTICAL COMMUNICATIONS AND NETWORKS Part II

Answer Sheet

Q1:

(a)

First, we need to convert output optical power into dBm:

$$P_{out}(dBm) = 10\log[P_{in}(mW)/1mW] = -20\ dBm;$$

Next, we calculate the input power in dBm:

$$P_{out}(dBm) = P_{in}(dBm) + \alpha L = -20\ dBm + (0.4\ dB/km \times 30\ km) = -8\ dBm;$$

In last step, we convert the output power unit into µW:

$$P_{out}(\mu W) = 1000\times10\text{^}[0.1\times P_{out}(dBm)] = 158\ \mu W$$

(b)

i. n1=1.445, Δ=0.18%,

   The normalized frequency can be calculated using the following equation:

$$V \approx \frac{2\pi}{\lambda} a n_1 \sqrt{2\Delta} = 2.51$$

ii. Number of modes can be estimated as:

$$M \approx V^2/2 = 3$$

(Note: the solution above is only an estimation, the answer will be counted as correct as long as it falls into the same range, and the approach is correct)

iii. In order to make the fiber operate in single mode, the normalized frequency needs to be less than 2.405

$$V \approx \frac{2\pi}{\lambda} a n_1 \sqrt{2\Delta} < 2.405$$

Based on the relation above, the index difference can be calculated as:

$$\Delta < 0.16\%$$

Q2:

(a)

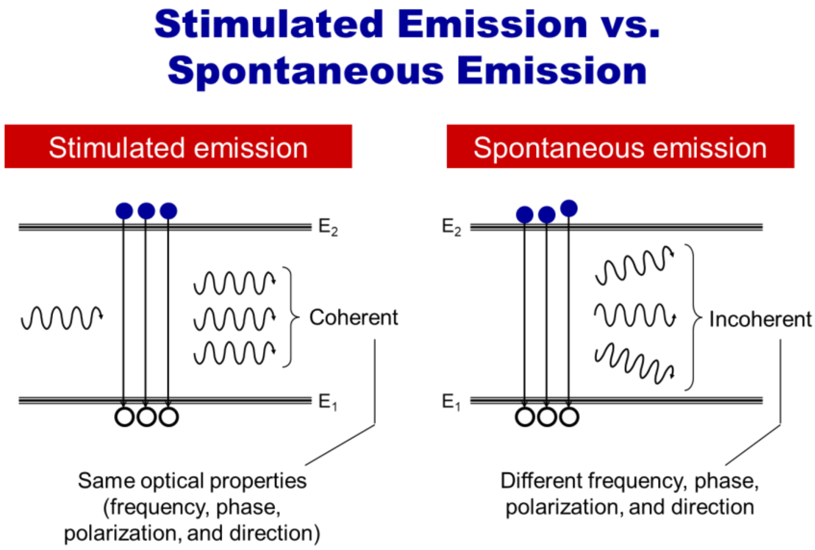
i. The number of longitudinal modes supported within the cavity can be calculated:

$$m = 2nLf/c = 2nL/(c*T) = 2nL/\lambda = 2*1.77*0.05/(0.00000056) = 3.2\times10^5$$

ii. The frequency separation (or free spectral range) can be calculated as:

$$FSR = c/2nL = 3\times10^8/(2*1.77*0.05) = 1.69\ \text{GHz}$$

(b)



- **Spontaneous emission:** the process that the electron jumps down from upper level, and recombine with the hole in the lower level, to emit one photon. The photons released from spontaneous emission are in-coherent. It will have different frequency, phase, polarization, as well as direction.
- **Stimulated emission:** the emitted photon from the spontaneous emission to excite more electrons to jump from conduction band to valence band, creating a new photon with identical **phase**, **frequency**, **polarization**, and **direction of travel** as the photons of the incident wave. That is coherent emission.

(c)

For APD, first, we calculate the responsivity without multiplication (M=1):

$$R = \frac{\eta q}{hf} = \frac{\eta q \lambda}{hc} = \frac{(0.72)(1.6\times10^{-19})(850\times10^{-9})}{(6.63\times10^{-34})(3\times10^{8})} = 0.49\ \text{A/W}$$

Then, the photocurrent without multiplication can be calculated:

$$I_0 = I/M = 500/100 = 5\ nA$$

Next, the multiplied photocurrent can be calculated:

$$P_0 = I_0/R = 5\times10^{-9}/0.49 = 10.16\ nW$$

(Note: there are different approaches to solve this problem)