5.1) $l = 80\,km$ $\quad A_s = 0.05\,dB$

$N_s = 16$ sections $\quad A_f = 0.2\,dB/km$

$A_c = 0.25\,dB$

a) $A_T = (N_s - 1)A_s + A_f \cdot l + 2A_c = 17.25\,dB$

$P_R = P_E - A_T \Leftrightarrow P_E = P_R + A_T = -35\,dBm + 17.25\,dB = -17.75\,dBm \rightsquigarrow 16.8 \times 10^{-3}\,mW = 16.8\,\mu W$ //

b) $A_T = (N_s - 2)A_s + A_f \cdot l' + 3A_c \Leftrightarrow \frac{A_T - 3A_c - 14A_s}{A_f} = l' = 79\,km$

Redução $= l - l' = 1\,km$ //

5.2) a) A: $P_{0:0} = 0.5\,mW$

$P_{0:1} = \pi \cdot P_{0:0} = 5\,mW$

$\bar{P}_0 = \frac{P_{0:0} + P_{0:1}}{2} = 2.75\,mW$

$n = 10\,dB \rightarrow 10$

B: $P_{0:0} = 0.5\,mW$

$P_{0:1} = \pi \cdot P_{0:0} = 2.5\,mW$

$\bar{P}_0 = \frac{P_{0:0} + P_{0:1}}{2} = 1.5\,mW$

$n = 7\,dB \rightarrow 5$

C: $P_{0:0} = 0.1\,mW$

$P_{0:1} = \pi \cdot P_{0:0} = 2\,mW$

$\bar{P}_0 = \frac{P_{0:0} + P_{0:1}}{2} = 1.05\,mW$

$n = 13\,dB \rightarrow 20$

b) A e B $\Rightarrow$ SLM $\quad$ c) $LB_{min} = 2.5\,GHz \Rightarrow$ B ✗ $\Rightarrow$ A ✓

C $\Rightarrow$ MLM

5.3 a) $\lambda = 1.55\,\mu m$ $\quad \sqrt{S_c} = 4\,pA/Hz^{1/2}$ $\quad BER = 10^{-9}$

$R_B = 2.5\,Gbit/s$ $\quad n = 0$

$\eta = 0.8$ $\quad B_{elm} = 0.65\,R_B$

a) $R_\lambda = \frac{1.55}{1.24} 0.8 = 1\,A/W$ $\quad Q = 6$ (Tabela)

$\bar{P}_{in} = \frac{1+\pi}{1-\pi} Q \frac{\sqrt{S_c} \cdot \sqrt{B_{elm}}}{R_\lambda} = 6 \cdot 4 \times 10^{-12} \cdot \sqrt{0.65 \cdot 2.5 \times 10^9} = 7.5 \times 10^{-7}\,W = -60\,dBW = -30\,dBm$

b) $NEP = 4\,pW/Hz^{1/2} = -114\,dBW/Hz^{1/2} = -84\,dBm/Hz^{1/2}$

c) $\bar{P}'_{in} = \frac{1+\pi}{1-\pi} \cdot Q \cdot NEP \cdot \sqrt{B_{elm}} = 6 \cdot 4\,pW/Hz^{1/2} \cdot \sqrt{0.65 \cdot 10 \times 10^9\,Hz} = 1.9 \times 10^{-6}\,W = -57\,dBW = -27\,dBm$

5.4) a) $LB_{Min} = 2.5\,GHz \Rightarrow$ B ✗ logo em A ou C e A é mais sensível $\Rightarrow$ é melhor $\Rightarrow$ A ✓

b) $NEP = \frac{1-\pi}{1+\pi} \frac{1}{Q\sqrt{B_{Em}}} \bar{P}_{in} \Rightarrow$ basta ordenar por $\frac{1}{\sqrt{B_{Em}}} \bar{P}_{in}$

A: $\frac{\bar{P}_{in}}{\sqrt{B_{Em}}} = 20\,pW/\sqrt{Hz}$

B: $\frac{\bar{P}_{in}}{\sqrt{B_{Em}}} = 25\,pW/\sqrt{Hz}$

C: $\frac{\bar{P}_{in}}{\sqrt{B_{Em}}} = 33\,pW/\sqrt{Hz}$

$NEP_A < NEP_B < NEP_C$

5.5 $\lambda = 1.55\mu m$ $A = 0.25 dB/km$ $\sqrt{S_c} = 3pA/\sqrt{Hz}$ $BER = 3 \times 10^{-10}$

$R_B = 155.52 Mbit/s$ $\bar{P}_0 = 0 dBm = 1 mW$ $B_{Em} = 0.7 \times R_B$

$d_T = 270 km$ $\eta = 0.8$ $r = 0$

$$\bar{P}_{1m} = \frac{1+r}{1-r} Q \frac{\sqrt{S_c}\sqrt{B_{Em}}}{R_\lambda} = 200 mW = 0,2 \mu W \Rightarrow -67 dBW = -37 dBm$$

$$R_\lambda = \eta \frac{\lambda}{1.24} = 1 A/W$$

$$BER = \frac{1}{2} erfc\left(\frac{q}{\sqrt{2}}\right) \Rightarrow 6 \times 10^{-10} = erfc\left(\frac{q}{\sqrt{2}}\right) \Leftrightarrow \frac{q}{\sqrt{2}} = 4.38 \Rightarrow q = 6.19$$

$$\bar{P}_{1,rec} = \bar{P}_0 - A \cdot d_s = \bar{P}_0 - A \frac{d_T}{3} = -22.5 dBm$$

Margem $= \bar{P}_{1,rec} - \bar{P}_1 = -22.5 dBm - (-37 dBm) = 14.5 dB$ // Permite ligação

$\Rightarrow > 6 dB$ //