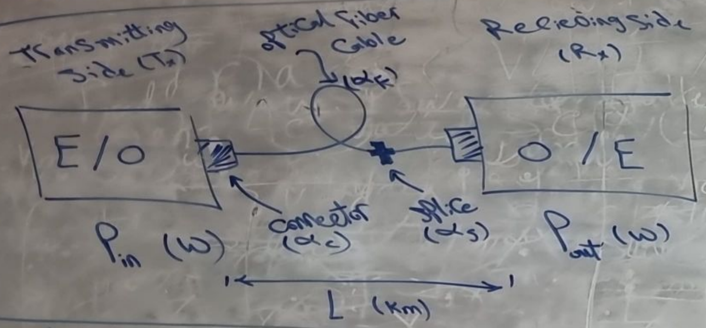
Calculation of attenuation in optical fiber communication



$$\boxed{\alpha_t\Big|_{dB} = 10\log\left(\frac{P_{in}}{P_{out}}\right) = P_{in}\Big|_{dBm} - P_{out}\Big|_{dBm}}$$

$$P = 10\,W$$

$$P\Big|_{dB} = 10\log 10 = 10\,dB$$

$$P\Big|_{dBm} = 10\log\left(\frac{10\,W}{1\,mW}\right) = 10\log\left(\frac{10}{10^{-3}}\right) = 40\,dBm$$

α_f : optical fiber attenuation coefficient (dB/km)

α_s : splice attenuation coefficient (dB/splice)

α_c : connector attenuation coefficient (dB/connector)

n : no. of sections

$(n-1)$: no. of splice

α_{Icl} : input coupling loss

α_{ocl} : output coupling loss

no. of sections

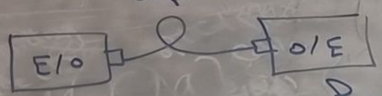
$$n = \frac{\text{total fiber length}}{\text{reel length}}$$

$$\boxed{\alpha_t\Big|_{dB} = \alpha_f \cdot L + (n-1)\alpha_s + 2\alpha_c + \alpha_{Icl} + \alpha_{ocl}}$$

Sheet 1

no. 1

$\alpha_f = 1.5$ dB/km



$P_{out} = ??$

$P_{in} = 0.5$ mW

L = 8 km

max. reel length = 2 km

$\alpha_s = 0.1$ dB/splice

$\alpha_{Icl} = 1$ dB

$\alpha_{ocl} = 2$ dB

$$n = \frac{\text{total fiber length}}{\text{reel length}} = \frac{8}{2} = 4$$

ANS

$$\alpha_t = \alpha_f \cdot L + (n-1)\alpha_s + 2\underbrace{\cancel{\alpha_c}}_{0} + \alpha_{Icl} + \alpha_{ocl}$$

$$\alpha_t|_{dB} = (1.5\times 8) + (3\times 0.1) + 1 + 2 = 15.3 \text{ dB}$$

$$\alpha_t|_{dB} = P_{in}|_{dBm} - P_{out}|_{dBm}$$

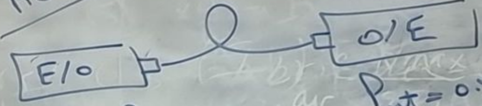
$$P_{out}|_{dBm} = P_{in}|_{dBm} - \alpha = 10\log\left(\frac{0.5\,\cancel{mW}}{1\,\cancel{mW}}\right) - 15.3 = -18.31 \text{ dBm}$$

$$P_{out} = -18.31 \text{ dBm}$$

$$P_{out} = 10^{-1.831} = 0.0148 \text{ mW} = 14.8\ \mu W$$

no. 2

$\alpha_f = ??$



$P_{out} = 0.45P$

$P_{in} = P$

L = 3.5 km

max. reel length = 3 km

$\alpha_s = 0.2$ dB/splice

$\alpha_{Icl} = 1$ dB

$\alpha_{ocl} = 0.8$ dB

$$n = \frac{\text{total fiber length}}{\text{reel length}} = \frac{3.5}{3} = 2$$

$$\alpha_t = 10\log\left(\frac{P_{in}}{P_{out}}\right) = 10\log\left(\frac{\cancel{P}}{0.45\cancel{P}}\right) = 3.47 \text{ dB}$$

$$\alpha_t = \alpha_f \cdot L + (n-1)\alpha_s + 2\underbrace{\cancel{\alpha_c}}_{0} + \alpha_{Icl} + \alpha_{ocl}$$

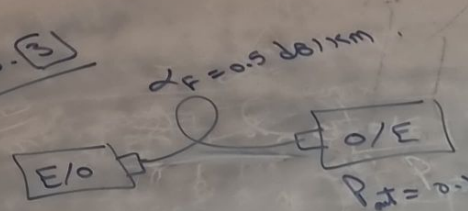
$$3.47 = 3.5\,\alpha_f + (1\times 0.2) + 1 + 0.8$$

$$\alpha_f = \frac{(3.47 - 0.2 - 1 - 0.8) \text{ dB}}{(3.5) \text{ km}}$$

$$\alpha_f = 0.42 \text{ dB/km}$$

no. 3

$\alpha_f = 0.5$ dB/km



$P_{out} = 0.1$ mW

$P_{in} = 1$ mW

$L = ??$

α_c, α_s, α_{Icl} and α_{ocl} → Ignored.

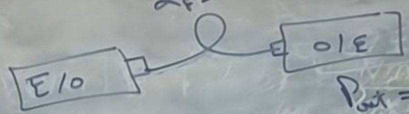
$$\alpha_t|_{dB} = 10\log\left(\frac{P_{in}}{P_{out}}\right) = 10\log\left(\frac{1\,mW}{0.1\,mW}\right) = 10\ dB$$

$$\alpha_t|_{dB} = \alpha_f . L + \underbrace{(n-1)\alpha_s + 2\alpha_c + \alpha_{Icl} + \alpha_{ocl}}_{\text{(Ignored)}}$$

$$L = \frac{\overset{dB}{\alpha_t}}{\underset{dB/km}{\alpha_f}} = \frac{10}{0.5} = 20\ km$$

no. 4

$\alpha_f = 1.5$ dB/km



$P_{out} = 0.3\ \mu W$

$P_{in} = ??$

$L = 12$ km

max. feel length = 3 km

$\alpha_s = 0.1$ dB/splice

$$n = \frac{\text{total fiber length}}{\text{reel length}} = \frac{12}{3} = 4$$

The Coupling losses are (2 dB) at each Transmit and recieve end. $\alpha_{Icl} = 2$ dB, $\alpha_{ocl} = 2$ dB

$$\alpha_t|_{dB} = \alpha_f . L + (n-1)\alpha_s + 2\underset{0}{\alpha_c} + \alpha_{Icl} + \alpha_{ocl}$$

$$\alpha_t = (1.5 \times 12) + (3 \times 0.1) + 2 + 2 = 22.3\ dB$$

$$\alpha_t|_{dB} = P_{in}|_{dBm} - P_{out}|_{dBm}$$

$$P_{in}|_{dBm} = P_{out}|_{dBm} + \alpha_t|_{dB} = 10\log\left(\frac{0.3\times10^{-6}}{1\times10^{-3}}\right) + 22.3 = -12.93\ dB_m$$

$$P_{in} = -12.93\ dB_m$$

$$P_{in} = 10^{-1.293} = 0.051\ mW = 51\ \mu W$$