EE 443 Fall 2019

Homework 2

Problem 4 Solution

https://www.oc2me.com/services/link-budget-calculation/
Problem 4  Optical Link Maximum Length  (20 points)

An optical power of 150 microwatts (150 $\mu$W) is launched into a fiber link. The optical fiber has an attenuation constant of 0.52 dB/km. We want to determine the maximum possible length of the optical link without signal amplification being allowed. The conditions pertaining to the optical link are that the receiver’s detector can detect a signal as weak as 2 microwatts (2 $\mu$W), and every 10 km an optical fiber joint (splicing two fiber sections together) must be included in the link, with each joint having a loss of 1.5 dB. How long (in km) can this fiber link be subject to these limitations?
Solution:

We begin by calculating our loss budget we are allowed down the fiber link. Power input = 150 μW and minimum detectable power = 2 μW. Thus, the allowable power loss is

\[
\text{Loss budget} = 10 \log_{10} \left( \frac{150 \, \mu W}{2 \, \mu W} \right) = 18.75 \, \text{dB}
\]

We know that every 10 km we must include an interconnect which by itself adds 1.5 dB of loss. In the first 10 km we find that we have a loss of

Loss over a distance of \( L \) is given by \( -\alpha L \), where \( \alpha = 0.52 \, \text{dB/km} \)
For $L = 10$ km, we have $-5.2$ dB of loss (minus sign indicates a loss), then we add $-1.5$ dB of loss from the interconnect. The next 10 km add another $-5.2$ dB of loss, followed by another $-1.5$ dB from interconnect, and so on until we reach $-18.75$ dB (out budget). Graphically this looks like the below diagram.
At 30 km we find we have -18.6 dB of loss, but if we then add an interconnect the added -1.5 dB takes us beyond the loss budget of -18.75 dB. So, we must stop at 30 km which allows us to remain within loss budget (by a margin of 0.15 dB).

**ANSWER:** 30 km

**Most made the mistake of using this combined model:**