

Calculating Optical Fiber Power Budget

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When building and designing a network, it is crucial part of the design to calculate the power budget of the optical fiber links in the network. The network engineers have to calculate the minimum amount of power that needs to be transmitted across the link, for the link to be reported as up and functioning. A weak signal through the link can cause either cause the link not to come up at all or perhaps become unstable and thereby resulting in errors, CRCs and a host of other issues.

To avoid confronting such issues at the last moment, network engineers calculate the power budget of a link, the total loss on link and determine the minimum power of the signal (in dBm) for the link to be productively functional.

The formula for power budget is given below:

$$PB = PT - PR$$

Where:

PB = Power Budget

PT = Transmitter Power

PR= Minimum Receiver Sensitivity

To calculate the power budget of, let us say, Garrettcom SFP-ESX (gigabit, multimode 1310 nm) which has minimum transmit power of -9.0 dBm and minimum receiver sensitivity of -19 dBm.

$$\begin{aligned} PB &= PT - PR \\ &= -9 - (-19) \\ &= 10 \text{ dBm} \end{aligned}$$

Our next step is to work the total loss of signal on the link. Please refer to the table below for the loss (in dBm) on fiber per kilometer, at connectors and at fiber splices.

Fiber Optic Cable Performance Standards

568 B3 added 50/125 fiber as an acceptable type and specifies the performance of cabled fiber as follows:

Fiber Type	Wavelength (nm)	Max Attenuation Coefficient (dB/km)	Bandwidth (MHz-km with overfilled launch)
50/125 (OM2, OM3, OM4)	850	3.5	500 (OM2), 2000 (OM3), 3500 (OM4)
	1300	1.5	500
62.5/125 (OM1)	850	3.5	160
	1300	1.5	500
Singlemode (OS1, OS2) (Premises)	1310	1.0	NA
	1550	1.0	NA
Singlemode (OS1, OS2) (Outside Plant)	1310	0.5	NA
	1550	0.5	NA

(Source: <http://www.thefoa.org/tech/tia568b3.htm>)

Connector Attenuation: 0.5 dBm

Splice Attenuation: 0.5 dBm

Formula for total attenuation of signal on the link is as follows:

Link Loss = (fiber length x attenuation per kilometer) + (number of splices x attenuation per splice) + (number of connectors x attenuation per connector) + (power margin)

For example, let us look at a gigabit multimode link which is 2 kilometers (1.62 miles) in length and has a diameter of 62.5/125 and has wavelength 1300 nm. The link also has no splice and two connectors. The safety margin is 5 dBm.

$$\begin{aligned}\text{Link Loss} &= (2 \times 1.5) + (0 \times 0.5) + (2 \times 0.5) + 5 \\ &= 3\text{dBm} + 0\text{ dBm} + 1\text{ dBm} + 5\text{ dBm} \\ &= 9\text{ dBm}\end{aligned}$$

Now we can calculate the power margin, which will help us determine if the power is sufficient to operate the receiver. The formula is:

$$\begin{aligned}\text{PM} &= \text{PB} - \text{LL} \\ &= 10\text{ dBm} - 9\text{ dBm} \\ &= 1\text{ dBm}\end{aligned}$$

As long as the power margin is > 0 (greater than zero), the link has sufficient power to operate the receiver. A power margin of 0 or less will not be sufficient operate the receiver.