What is a link budget?

Link budget is used in order to predict the amount of light required to ensure an uninterrupted communications link. It is a 'worst case scenario' calculation for a data transmission path. Optical transmission link budgets are calculated using four main parameters: minimum transmitter power, maximum connector insertion loss, fiber optic cable transmission loss and maximum receiver sensitivity. Transmitter power and receiver sensitivity are absolute values (e.g. Watts or dBm), whereas the fiber optic cable transmission loss and connector insertion loss are relative values (e.g. % loss), which is independent of the actual power level involved. This means that the loss at different points along a link can be the same number showing a consistent fiber path or different…showing a bad segment. Fiber optic cable has the same loss per measured segment, so using this system helps engineers identify faults.

The Decibel is a logarithmic unit which means there is not a linear relationship of light lost over a cable segment.10 dB of loss equals a loss of optical power in a system of 90%. 20 dB of loss equals 99%. And 30 dB of loss equals 99.9% of loss. 30 dB is typically the most loss a communications system can have since 10^{-10} error count cannot be factored with less than .1% of light.

An example of a fiber optic network segment using a standard power transmitter

Minimum optical transmitter power (Tx)	-8 dBm	Loss of 1st fiber optic cable section	6.6 dB
Maximum optical receiver sensitivity (Rx)	-21 dBm	Maximum insertion loss of connector mated pair	2.0 dB
		Loss of 2nd fiber optic cable section	4.2 dB
'Worst Case' transceiver link budget	13 dB	'Worst Case' loss along the fiber run	12.8 dB
Network segment link budget buffer = 0.2 dB			

What does this mean for my link?

The above table shows an example network segment with a standard power transmitter. Here, we have calculated the worst case transceiver budget and compared it to the maximum loss along the fiber run. That delta is our link budget buffer. In this case, we know our link will only have 0.2 dB of overhead during 'worst case' conditions. This value is too small because the margin for error is 3 dB in a fiber link. If this number is too small or a negative value you will have to rethink your design. Three main changes that can help remedy a low link budget buffer are higher powered transmitters, higher sensitivity receivers, and lower insertion loss connectors. All of which COTSWORKS can provide.

An example of a fiber optic network segment using a high power transmitter

Minimum optical transmitter power (Tx)	-5 dBm	Loss of 1st fiber optic cable section	6.6 dB
Maximum optical receiver sensitivity (Rx)	-21 dBm	Maximum insertion loss of connector mated pair	2.0 dB
		Loss of 2nd fiber optic cable section	4.2 dB
'Worst Case' transceiver link budget	16 dB	'Worst Case' loss along the fiber run	12.8 dB
Network segment link budget buffer = 3.2 dB			

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How much measurement resolution do I need?

Test equipment should have a resolution of 0.01 dB (0.23%) since some connector losses are now rated at 0.1 dB. Any measurement where that resolution is required for certification must be done in a stable temperature and vibration environment.

Does the speed of the optoelectric transceiver make a difference to the link budget?

The slower the speed of the link the more tolerant the system will be for loss. However, newer generations of parts continue to improve laser power and receiver efficiency. So, some of the most efficient systems are also some of the fastest.

Does temperature affect link budget?

Yes. Some parts can handle wider temperature ranges without failing. Typically, all parts become less efficient since the electrical conversion is less efficient at higher temperatures. Lower temperatures have different effects based upon the type of light source. Typically, the min/max values provided by the component manufacturers typically take temperature into consideration.

Does cable type matter to link loss?

Yes. Multimode cable contributes more loss than single-mode. Single-mode also has fewer problems with dispersion, but it is more sensitive to bending. All cable types are inherently impure and contribute loss, which means they all have a rated loss per distance segment. The shorter the link, the less that cable type is a factor.

How much light is left at the “end of the line?”

The table below provides a chart of the amount of loss and light remaining

dB	Percentage of Power	dB	Percentage of Power	dB	Percentage of Power	dB	Percentage of Power	dB	Percentage of Power
-60	0.00010%	-40	0.01000%	-20	1.0000%	0	100.00%	20	10000.00%
-59	0.00013%	-39	0.01259%	-19	1.2589%	1	125.89%	21	12589.25%
-58	0.00016%	-38	0.01585%	-18	1.5849%	2	158.49%	22	15848.93%
-57	0.00020%	-37	0.01995%	-17	1.9953%	3	199.53%	23	19952.62%
-56	0.00025%	-36	0.02512%	-16	2.5119%	4	251.19%	24	25118.86%
-55	0.00032%	-35	0.03162%	-15	3.1623%	5	316.23%	25	31622.78%
-54	0.00040%	-34	0.03981%	-14	3.9811%	6	398.11%	26	39810.72%
-53	0.00050%	-33	0.05012%	-13	5.0119%	7	501.19%	27	50118.72%
-52	0.00063%	-32	0.06310%	-12	6.3096%	8	630.96%	28	63095.73%
-51	0.00079%	-31	0.07943%	-11	7.9433%	9	794.33%	29	79432.82%
-50	0.00100%	-30	0.10000%	-10	10.0000%	10	1000.00%	30	100000.00%
-49	0.00126%	-29	0.12589%	-9	12.5893%	11	1258.93%	31	125892.54%
-48	0.00158%	-28	0.15849%	-8	15.8489%	12	1584.89%	32	158489.32%
-47	0.00200%	-27	0.19953%	-7	19.9526%	13	1995.26%	33	199526.23%
-46	0.00251%	-26	0.25119%	-6	25.1189%	14	2511.89%	34	251188.64%
-45	0.00316%	-25	0.31623%	-5	31.6228%	15	3162.28%	35	316227.77%
-44	0.00398%	-24	0.39811%	-4	39.8107%	16	3981.07%	36	398107.17%
-43	0.00501%	-23	0.50119%	-3	50.1187%	17	5011.87%	37	501187.23%
-42	0.00631%	-22	0.63096%	-2	63.0957%	18	6309.57%	38	630957.34%
-41	0.00794%	-21	0.79433%	-1	79.4328%	19	7943.28%	39	794328.23%
								40	1000000.00%

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