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Power Budget for Single Mode Optical Fiber

Ajay Kumar

Abstract: ***The allocation of power losses between optical source and detector is referred to as the power budget. To ensure that the fiber system has sufficient power for correct operation, we need to calculate the span's power budget, which is the maximum amount of power it can transmit. Transmission distance depends on transmitter output power, receiver's sensitivity, fiber quality, splice loss, connector loss, safety margin and signal losses caused by other factors. The reliability or performance of a fiber optic communication system can be enhanced through careful selection and matching of all the subparts (transmitter, fiber optic, receiver, connectors).The optic fiber should be matched and verified according to its applications. It should be stresses that the optimization of communication system based on fiber optics has quite a number of parameters. The only way to enhance on such system is to use a thorough designing approach and tuning it with the feed-back received from an economical analysis.***

Keywords: ***Power Budget, transmitter power, receiver sensitivity, connector loss & splice loss.***

I. INTRODUCTION

The allocation of power losses between optical source and detector is referred to as the power budget. The power budget is obtained by first determining the optical power emitted by the source, usually expressed in dBm, and subtracting the power (expressed in same units, e.g., dBm) required by the detector to achieve the design quality of performance[1-5].

To ensure that the fiber system has sufficient power for correct operation, we need to calculate the span's power budget, which is the maximum amount of power it can transmit. From a design perspective, worst-case analysis calls for assuming minimum transmitter power and minimum receiver sensitivity. This provides for a margin that compensates for variations of transmitter power and receiver sensitivity levels [2-6].

In order to implement or design a fiber-optic circuit, a span analysis is recommended to make certain the system will work over the proposed link. Both the passive and active components of the circuit have to be included in the loss-budget calculation. Passive loss is made up of fiber loss, connector loss, splice loss, and losses involved with couplers or splitters in the link. Active components are system gain, wavelength, transmitter power, receiver sensitivity, and dynamic range.

The design procedure requires the selection of the most advantageous combination of source, fiber and detector types that best meets the system requirements. Cost is also considered[1-2].

Optical Power Budget for a System contains a Transmitter, Amplifier, Receiver and Splices

For a system consisting of a transmitter, amplifier, receiver and splices we can calculate power budget by knowing the parameters of the link (lengths of runs) and optical components used.

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Ajay Kumar, System Analyst, H.D. Jain College, Arrah, Bihar, India.

The loss of signal can be calculated for any point of the path. This can be best seen in the example shown below:

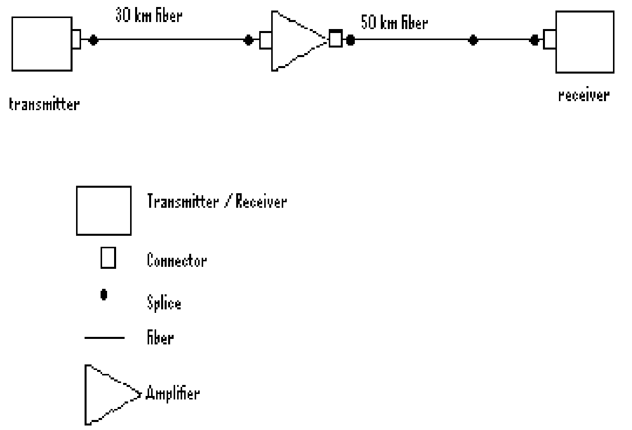

Fig.3.11: Diagram of an optical link,

The communication system consists of the transmitter and receiver, the optical link contains optical amplifier, 4 optical connectors and 5 splices. The following table gives for each item its attenuation or gain. With these values one can appropriately choose the sensitivity of the receiver:

Tx power:	3dBm
Connector loss:	0.15dB
Splice loss:	0.15dB
Amplifier gain:	10dB
Fiber optic loss:	0.2 dB/km

Calculations are performed for III transmission window (fiber attenuation of 0.2 dB km). The total loss of optical link depends on its length and the number and quality (attenuation) of optical connectors and splices. The total attenuation of the link is the sum of:

fiber optic loss:(30 km + 50 km) x 0.2 dB/km = 16 dB

attenuation of connectors:4 x 0.15 dB = 0.60dB

attenuation of splices: 5 x 0.15 dB = 0.75 dB

P_l = 16 dB + 0.60 dB + 0.75dB = 17.35 dB

The total gain of the link is in this case equal to the amplification of the optical amplifier.

P_g = 10 dB

When designing a link, it should be taken into account the aging of the electro-optical element of the transmitter (typically 1 dB ... 3 dB), and the effect of temperature on electronic and electro-optical devices (typically +/- 2dB). A good safety margin is 6 dB.

P_m = 6 dB

To select the receiver's sensitivity at the end of the optical path it is sufficient to rearrange and solve the equation:

$P_{tx} - P_{rx} < P_s - P_g + P_m$

$P_{rx} > P_{tx} - P_s - P_g + P_m$

$P_{rx} >$ 3 dBm - 17.35 dB +10 dB - 6 dB

$P_{rx} >$ -10.35 dB

The receiver should provide sensitivity better than -10.35 dBm.

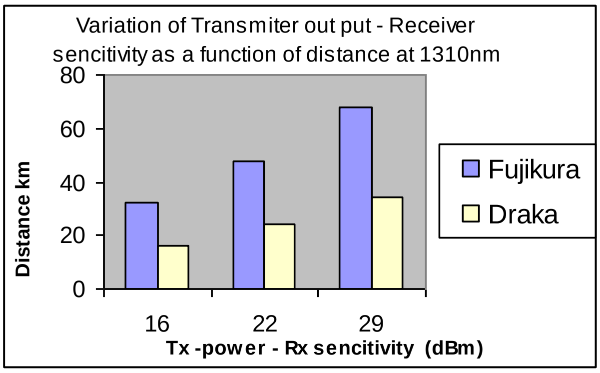

Fig.1 : Variation of available power (transmitter output-receiver sensitivity) as function of distance (km) at 1310 nm.

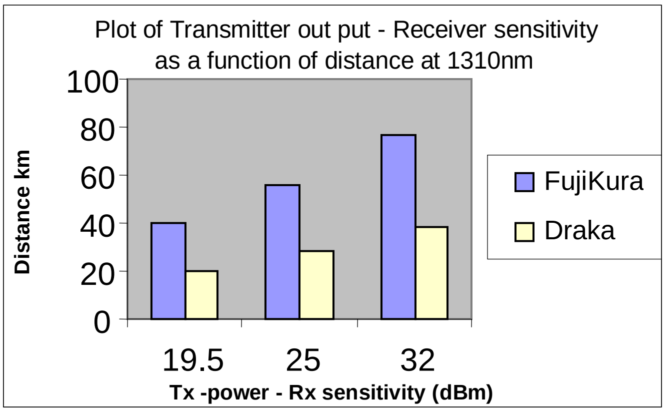

Fig.2: Variation of available power (transmitter output-receiver sensitivity) as function of distance (km) at 1310 nm.

Fig.1 & 2 shows that transmission distance is different for the two different fibers. It (transmission distance) is higher for Fujikura made fiber than that of Draka. The availability of same power does not ensure same optical path length, but, it depends on fiber quality.

II. LIMITATIONS OF POWER BUDGET

Power budget calculation can be used in a number of ways, for example if the fiber attenuation was known then a system designer could use a power budget calculation to determine the maximum distance between the transmitter and receiver or between regenerators. This distance is called the power-limited distance of the link.

However, the power budget calculations may become significantly more complex for two reasons:

(a) A number of extra factors may be included in the power budget calculation. For example a margin may be included to account for variations with temperature and age. The transmitter output power for example may vary with temperature and decrease with time over a number of years. To account for this a transmitter degradation margin is included, which is typically 1 dB. This appears in the power budget calculation as if it is a "real" attenuation, whereas in practice when the system first becomes operational and assuming the temperature is correct the received power would be 1 dB more than that predicted by the power budget calculation[5-8].

(b) All the power level and attenuation values used in the power budget calculation above are average values. When the optical transmission system is installed some variation in these values will naturally take place. The system designer has little control over such variations and therefore must resort to statistical techniques to ensure that the power budget calculation is realistic. In a statistical power budget calculation the designer will not only use an average value for a quantity, but also a value called the standard deviation σ, which is a statistical measure of how actual values vary from the average value. How the standard deviation is used depends on the quantity in question, however for attenuation values the system designer is concerned with values that are above average. For example 84.13% of the values are contained between zero and one standard deviation (1σ) above average, 97.73% within 2σ above average and 99.87% within 3σ above average. In power budget calculations, generally, the 2σ value is considered the worst case value[8-9].

Ignoring the statistical nature of component performance by using worst case values, in every case can create extremely over-conservative designs. If for example, in finding the total loss caused by fusion splices, the worst case loss for a fusion splice is simply multiplied by the number of splices involved, the result would be a figure for the total splice loss that would virtually never occur in practice8-10.

III. CONCLUSIONS

The reliability of the communication of fiber optic systems can be done only through a careful selection and matching of all the subparts (transmitter, fiber optic, receiver, connectors).The fiber optic should be matched to the application such that it satisfied the overall power budget. It should be stresses that the optimization of communication system based on fiber optics has quite a number of parameters. The only way to enhance on such system is technical improvements and tune it with the feed-back received from an economical analysis.

In nut shell, the system should be effective, useful and economically viable.

REFERENCES

[1] R. AGGARWAL, P. MOORE, Digital communication for protection. III: Fiber optics, IEE Power Engineering Journal, vol. 8, no. 5, pp. 241-246, Oct. 1994.
[2] John M. Senior, Optical Fiber Communication, Principals And Practice, 2nd edition, Prentice Hall, 1992.
[3] Ivan P. Kaminow and Thomas L.Loch, Optical Fiber Telecommunications IIIA, Academic Press, 1997.
[4] G. Agrawal, “Fiber-Optic Communication Systems”, New York, N.Y.: John Wiley & Sons, pp. 172, 1997.
[5] Edward A. Lee and David G. Messerchmitt, Digital Communication, Kluwer Academic Publishers, Boston, 1988.
[6] Theodore S. Rappaport, Wireless Communication: Principals and Practice, N.J., Prentice Hall PTR, 1996.
[7] B. Mukherjee, “Optical Communication Networks”, McGraw-Hill, New York, 2003.
[8] D. Banerjee and B. Mukherjee, “A Practical Approach for routing and Wavelength Assignment in Large Wavelength Routed Optics Networks”, IEEE Journal on Selected Areas in Communications, vol.14, no.5, pp.903-908, June 1996.
[9] C. YEH, Handbook of fiber optics. Theory and applications, Academic Press Inc., San Diego, CA, USA, pp.187-211, 1990
[10] G. SNELL, An introduction of fiber optics and broadcasting, SMPTE Journal, vol. 105, no. 4, pp. 1-7,1996.