Link budget analysis of 25 and 10 Gb/s using GI-POF

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Introduction and objectives

- Link budget simulations were requested by Yuji Watanabe using GI-POF fiber proposed by him to be included in the baseline
- Simulation conditions, including Watanabe's request:
  - Link model of [1] was used
  - Transmission scheme of [2] already adopted in D1.0
  - TRUMPF 850nm 25G VCSELs of [3] with limited current for reliability (see slide 13 of [3])
  - GI-POF attenuation: 85 dB/km @ 980nm
  - GI-POF BW_{CD} = 9670 MHz·km @ 980nm (calculated for U_0 = 1310 nm, S_0 = 0.06 ps/nm^2·km, U_W = 0.6 nm)
  - GI-POF EMB, three cases have been considered: 200, 250, 300 MHz·km
  - GI-POF BW_{eff} : 200, 250, 300 MHz·km
  - For data-rate of 25 Gb/s, only 15 meters fiber length is considered
  - For data-rate of 10 Gb/s, 40 meters are used
  - Worst-case link budget is reported (both TX and RX operating at 125ºC, slow process corners)

Link budget for 25 Gb/s — 15m, EMB=200 MHz·km

25 Gb/s link budget assessment (ERmin = 4 dB)

Parameter	Value	
VCSEL SE variation in the same bin (dB)	0.50	**A**
VCSEL aging (dB)	1.00	**B**
VCSEL to TP2 max coupling loss (dB)	2.50	**C**
$IL_{TP1\text{-}to\text{-}TP2}$, max (dB)	**4.00**	**D = A + B + C**
$IL_{TP3\text{-}to\text{-}TP4}$, max (dB)	**2.50**	**E**
Insertion loss per inline connection, IL_{IC} max (dB)	**2.00**	**F**
Number of inline connections (N_{IC})	**4**	**G**
Macrobend insertion loss, max (dB)	0.20	**H**
Microbend insertion loss, max (dB)	0.00	**I**
Bending insertion loss, IL_{BEND} max (dB)	0.20	**J = H + I**
Fiber attenuation (dB/km)	85.00	**K**
Channel attenuation, $IL_{TP2\text{-}to\text{-}TP3}$, max (dB)	**9.48**	**L = (F × G) + J + (15/1000 × K)**
$IL_{TP1\text{-}to\text{-}TP4}$, max (dB)	**15.98**	**M = D + E + L**
OMA_{TP1} min (dBm)	**-0.60**	**N**
OMA_{TP2} min (dBm)	**-4.60**	**O = N - D**
OMA_{TP4} max (dBm)	**-15.30**	**P**
OMA_{TP3} max (dBm)	**-12.80**	**Q = P + E**
Power budget (dB)	**8.20**	**R = O - Q**
Unallocated margin (dB)	**-1.28**	**S = R - L**

Link budget for 25 Gb/s — 15m, EMB=250 MHz·km

25 Gb/s link budget assessment (ERmin = 4 dB)

Parameter	Value	
VCSEL SE variation in the same bin (dB)	0.50	**A**
VCSEL aging (dB)	1.00	**B**
VCSEL to TP2 max coupling loss (dB)	2.50	**C**
$IL_{TP1\text{-}to\text{-}TP2}$, max (dB)	**4.00**	**D = A + B + C**
$IL_{TP3\text{-}to\text{-}TP4}$, max (dB)	**2.50**	**E**
Insertion loss per inline connection, IL_{IC} max (dB)	**2.00**	**F**
Number of inline connections (N_{IC})	**4**	**G**
Macrobend insertion loss, max (dB)	0.20	**H**
Microbend insertion loss, max (dB)	0.00	**I**
Bending insertion loss, IL_{BEND} max (dB)	0.20	**J = H + I**
Fiber attenuation (dB/km)	85.00	**K**
Channel attenuation, $IL_{TP2\text{-}to\text{-}TP3}$, max (dB)	**9.48**	**L = (F × G) + J + (15/1000 × K)**
$IL_{TP1\text{-}to\text{-}TP4}$, max (dB)	**15.98**	**M = D + E + L**
OMA_{TP1} min (dBm)	**-0.60**	**N**
OMA_{TP2} min (dBm)	**-4.60**	**O = N - D**
OMA_{TP4} max (dBm)	**-15.60**	**P**
OMA_{TP3} max (dBm)	**-13.10**	**Q = P + E**
Power budget (dB)	**8.50**	**R = O - Q**
Unallocated margin (dB)	**-0.98**	**S = R - L**

Link budget for 25 Gb/s — 15m, EMB=300 MHz·km

25 Gb/s link budget assessment (ERmin = 4 dB)

Parameter	Value	
VCSEL SE variation in the same bin (dB)	0.50	**A**
VCSEL aging (dB)	1.00	**B**
VCSEL to TP2 max coupling loss (dB)	2.50	**C**
$IL_{TP1\text{-}to\text{-}TP2}$, max (dB)	**4.00**	**D = A + B + C**
$IL_{TP3\text{-}to\text{-}TP4}$, max (dB)	**2.50**	**E**
Insertion loss per inline connection, IL_{IC} max (dB)	**2.00**	**F**
Number of inline connections (N_{IC})	**4**	**G**
Macrobend insertion loss, max (dB)	0.20	**H**
Microbend insertion loss, max (dB)	0.00	**I**
Bending insertion loss, IL_{BEND} max (dB)	0.20	**J = H + I**
Fiber attenuation (dB/km)	85.00	**K**
Channel attenuation, $IL_{TP2\text{-}to\text{-}TP3}$, max (dB)	**9.48**	**L = (F × G) + J + (15/1000 × K)**
$IL_{TP1\text{-}to\text{-}TP4}$, max (dB)	**15.98**	**M = D + E + L**
OMA_{TP1} min (dBm)	**-0.60**	**N**
OMA_{TP2} min (dBm)	**-4.60**	**O = N - D**
OMA_{TP4} max (dBm)	**-15.80**	**P**
OMA_{TP3} max (dBm)	**-13.30**	**Q = P + E**
Power budget (dB)	**8.70**	**R = O - Q**
Unallocated margin (dB)	**-0.78**	**S = R - L**

Link budget for 10 Gb/s — 40m, EMB=200 MHz·km

10 Gb/s link budget assessment (ERmin = 3 dB)

Parameter	Value	
VCSEL SE variation in the same bin (dB)	0.50	**A**
VCSEL aging (dB)	1.00	**B**
VCSEL to TP2 max coupling loss (dB)	2.50	**C**
$IL_{TP1\text{-}to\text{-}TP2}$, max (dB)	**4.00**	**D = A + B + C**
$IL_{TP3\text{-}to\text{-}TP4}$, max (dB)	**2.50**	**E**
Insertion loss per inline connection, IL_{IC} max (dB)	**2.00**	**F**
Number of inline connections (N_{IC})	**4**	**G**
Macrobend insertion loss, max (dB)	0.20	**H**
Microbend insertion loss, max (dB)	0.00	**I**
Bending insertion loss, IL_{BEND} max (dB)	0.20	**J = H + I**
Fiber attenuation (dB/km)	85.00	**K**
Channel attenuation, $IL_{TP2\text{-}to\text{-}TP3}$, max (dB)	**11.60**	**L = (F × G) + J + (40/1000 × K)**
$IL_{TP1\text{-}to\text{-}TP4}$, max (dB)	**18.10**	**M = D + E + L**
OMA_{TP1} min (dBm)	**-1.70**	**N**
OMA_{TP2} min (dBm)	**-5.70**	**O = N - D**
OMA_{TP4} max (dBm)	**-20.00**	**P**
OMA_{TP3} max (dBm)	**-17.50**	**Q = P + E**
Power budget (dB)	**11.80**	**R = O - Q**
Unallocated margin (dB)	**0.20**	**S = R - L**

Assumed same optical connectivity of 25Gb/s (i.e. same insertion losses).
In [3], for OM3 fiber, the losses were relaxed wrt 25 Gb/s case

Link budget for 10 Gb/s — 40m, EMB=250 MHz·km

10 Gb/s link budget assessment (ERmin = 3 dB)

Parameter	Value	
VCSEL SE variation in the same bin (dB)	0.50	**A**
VCSEL aging (dB)	1.00	**B**
VCSEL to TP2 max coupling loss (dB)	2.50	**C**
$IL_{TP1\text{-}to\text{-}TP2}$, max (dB)	**4.00**	**D = A + B + C**
$IL_{TP3\text{-}to\text{-}TP4}$, max (dB)	**2.50**	**E**
Insertion loss per inline connection, IL_{IC} max (dB)	**2.00**	**F**
Number of inline connections (N_{IC})	**4**	**G**
Macrobend insertion loss, max (dB)	0.20	**H**
Microbend insertion loss, max (dB)	0.00	**I**
Bending insertion loss, IL_{BEND} max (dB)	0.20	**J = H + I**
Fiber attenuation (dB/km)	85.00	**K**
Channel attenuation, $IL_{TP2\text{-}to\text{-}TP3}$, max (dB)	**11.60**	**L = (F × G) + J + (40/1000 × K)**
$IL_{TP1\text{-}to\text{-}TP4}$, max (dB)	**18.10**	**M = D + E + L**
OMA_{TP1} min (dBm)	**-1.70**	**N**
OMA_{TP2} min (dBm)	**-5.70**	**O = N - D**
OMA_{TP4} max (dBm)	**-20.50**	**P**
OMA_{TP3} max (dBm)	**-18.00**	**Q = P + E**
Power budget (dB)	**12.30**	**R = O - Q**
Unallocated margin (dB)	**0.70**	**S = R - L**

Assumed same optical connectivity of 25Gb/s (i.e. same insertion losses).
In [3], for OM3 fiber, the losses were relaxed wrt 25 Gb/s case

Link budget for 10 Gb/s — 40m, EMB=300 MHz·km

10 Gb/s link budget assessment (ERmin = 3 dB)

Parameter	Value	
VCSEL SE variation in the same bin (dB)	0.50	**A**
VCSEL aging (dB)	1.00	**B**
VCSEL to TP2 max coupling loss (dB)	2.50	**C**
$IL_{TP1\text{-}to\text{-}TP2}$, max (dB)	**4.00**	**D = A + B + C**
$IL_{TP3\text{-}to\text{-}TP4}$, max (dB)	**2.50**	**E**
Insertion loss per inline connection, IL_{IC} max (dB)	**2.00**	**F**
Number of inline connections (N_{IC})	**4**	**G**
Macrobend insertion loss, max (dB)	0.20	**H**
Microbend insertion loss, max (dB)	0.00	**I**
Bending insertion loss, IL_{BEND} max (dB)	0.20	**J = H + I**
Fiber attenuation (dB/km)	85.00	**K**
Channel attenuation, $IL_{TP2\text{-}to\text{-}TP3}$, max (dB)	**11.60**	**L = (F × G) + J + (40/1000 × K)**
$IL_{TP1\text{-}to\text{-}TP4}$, max (dB)	**18.10**	**M = D + E + L**
OMA_{TP1} min (dBm)	**-1.70**	**N**
OMA_{TP2} min (dBm)	**-5.70**	**O = N - D**
OMA_{TP4} max (dBm)	**-20.70**	**P**
OMA_{TP3} max (dBm)	**-18.20**	**Q = P + E**
Power budget (dB)	**12.50**	**R = O - Q**
Unallocated margin (dB)	**0.90**	**S = R - L**

Assumed same optical connectivity of 25Gb/s (i.e. same insertion losses).
In [3], for OM3 fiber, the losses were relaxed wrt 25 Gb/s case

Conclusions

- Link budget for 25 Gb/s
  - The performance (receiver sensitivity) is very limited by the small EMB of GI-POF
  - The link budget is also affected by the high attenuation of the fiber
  - As result, 4 inline connection cannot be supported even with 15 meters channel, if the maximum insertion loss per inline connector is assumed the same of OM3

- Link budget for 10 Gb/s
  - 40 meters channel length with 4 inline connections can be supported
  - However, due to the high attenuation of the GI-POF, the maximum insertion loss per inline connection needs to be kept as in the case of 25 Gb/s with no option to relax specifications for 10 Gb/s as in the case of OM3

- GI-POF EMB
  - Several values of EMB have been considered for simulation per request
  - EMB characterization results should be presented to the TF for the two wavelengths under consideration, 850nm and 980nm

References

- [1] R. Pérez-Aranda, “OMEGA link model,” September 2020, [Online], Available: https://www.ieee802.org/3/cz/public/29_sep_2020/perezaranda_3cz_01_290920_link_model.pdf

- [2] R. Pérez-Aranda, “802.3cz baseline proposal,”, November 2020, [Online], Available: https://www.ieee802.org/3/cz/public/nov_2020/perezaranda_3cz_01a_1120_baseline.pdf

- [3] R. Pérez-Aranda, “Reliability constrained link budget assessment for 25 and 10 Gb/s,” December 2020, [Online], Available: https://www.ieee802.org/3/cz/public/22_dec_2020/perezaranda_3cz_02a_221220_reliability_linkbdget.pdf

Thank you!