Re: Comments on 200/400G-ER4/8 Link Budgets (#38,#39); And is a New PHY required?

Frank Chang
Source Photonics
IEEE P802.3cn Task Force

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100G ER4 Deployment Status (1)

- Current 100GBASE-ER4 deployment in practice use the option of reach lite to guarantee 30km over worst-case fibers and ER4 40km is considered as an engineered link

P802.3ba initiated from 01.08, ratified by 06.10

Table 88–6—100GBASE–LR4 and 100GBASE–ER4 operating ranges

PMD type	Required operating range
100GBASE–LR4	2 m to 10 km
100GBASE–ER4	2 m to 30 km
	2 m to 40 km[a]

[a]Links longer than 30 km for the same link power budget are considered engineered links. Attenuation for such links needs to be less than the worst case specified for B1.1, B1.3, or B6_A single-mode fiber.

100GbE-ER4 specs based on available technology at that time: EML TX & SOA RX (no 25G APD technology)

Later ER4 power budget and RX Sens., are relaxed for example by 3dB, to make 25G APD implementations practical

- Another industrial observation, 4WDM MSA define an even more cost-effective set of specifications for reaches up to 40 km by leveraging RS-FEC.

4WDM MSA initiated from 09.16, after 802.3ba & completed by 09.17

Table 2-2: 4WDM-20 and 4WDM-40 operating range

PMD type	Required operating range
100GE-4WDM-20	2 m to 20 km
100GE-4WDM-40	2 m to 40 km

The bit error ratio (BER) shall be less than 5×10^{-5}.

Critical specs was developed to enable cost-effective and low-power 100G networking where reach longer than 10 km is require

100G ER4 Deployment Status (2)

- 100G illustrative budgets in Table 88-9 for 30 and 40km show additional loss of 3dB allowed for 30km on top of worst-case fiber loss, different from any other PMDs, such as 100GBASE-LR4, but fail to specify or provide any guideline on how to allocate this 3dB if no additional loss is needed, rendering high module cost and introducing some difficulty in facilitating module interoperability.

Current definition of additional 3dB is allowed on top of worst-case fiber loss, which seems unnecessary.

Seems not good idea to ask market to decide how to interpret and implement 30/40km

Table 88–9—100GBASE–LR4 and 100GBASE–ER4 illustrative link power budgets

Parameter	100GBASE-LR4	100GBASE-ER4		Unit
Power budget (for maximum TDP)	8.5	—		dB
Power budget	—	21.5		dB
Operating distance	10	30	40[a]	km
Channel insertion loss	6.3[b]	15	18	dB
Maximum discrete reflectance	–26	–26		dB
Allocation for penalties[c] (for maximum TDP)	2.2	—		dB
Allocation for penalties[c]	—	3.5		
Additional insertion loss allowed	0	3	0	dB

[a]Links longer than 30 km are considered engineered links. Attenuation for such links needs to be less than the worst case for B1.1, B1.3, or B6_A single-mode cabled optical fiber

[b]The channel insertion loss is calculated using the maximum distance specified in Table 88–6 for 100GBASE–LR4 and fiber attenuation of 0.43 dB/km at 1295 nm plus an allocation for connection and splice loss given in 88.11.2.1.

[c]Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

The Upgrades to 400G ER8

- Current 400G illustrative budgets in Table 122-13 for 30 and 40km follows exactly same 100G format, so may expect similar difficulty in fields.

Table 122–13—200GBASE-FR4, 200GBASE-LR4, 200GBASE-ER4, 400GBASE-FR8, ~~and~~ 400GBASE-LR8, and 400GBASE-ER8 illustrative link power budgets

Parameter	200GBASE-FR4	400GBASE-FR8	200GBASE-LR4	400GBASE-LR8	200GBASE-ER4		400GBASE-ER8		Unit
Power budget (for maximum TDECQ): for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	~~7.6~~7.4 ~~7.7~~7.5	~~7.4~~7.2 ~~7.5~~7.3	~~10.2~~10 ~~10.3~~10.1	~~10.1~~9.9 ~~10.2~~10	21.7 —		21.9 —		dB dB
Operating distance	2		10		30	40[a]	30	40[a]	km
Channel insertion loss (max)	4[b]		6.3		15	18	15	18	dB
Channel insertion loss (min)	0				10		10		dB
Maximum discrete reflectance	See 122.11.2.2		See 122.11.2.2		See 122.11.2.2		See 122.11.2.2		dB
Allocation for penalties[c] (for maximum TDECQ): for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	~~3.6~~3.4 ~~3.7~~3.5	~~3.4~~3.2 ~~3.5~~3.3	~~3.9~~3.7 ~~4~~3.8	~~3.8~~3.6 ~~3.9~~3.7	3.7 —		3.9 —		dB dB
Additional insertion loss allowed	0		0		3	0	3	0	dB

[a] Links longer than 30 km are considered engineered links. Attenuation for such links needs to be less than the worst case for cables containing IEC 60793-2-50 type B1.1, type B1.3, or type B6_a single-mode cabled optical fiber.

[b] The channel insertion loss is calculated using the maximum distance specified in Table 122–8 for 200GBASE-FR4 and 400GBASE-FR8 and fiber attenuation of 0.5 dB/km plus an allocation for connection and splice loss given in 122.11.2.1.

[c] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

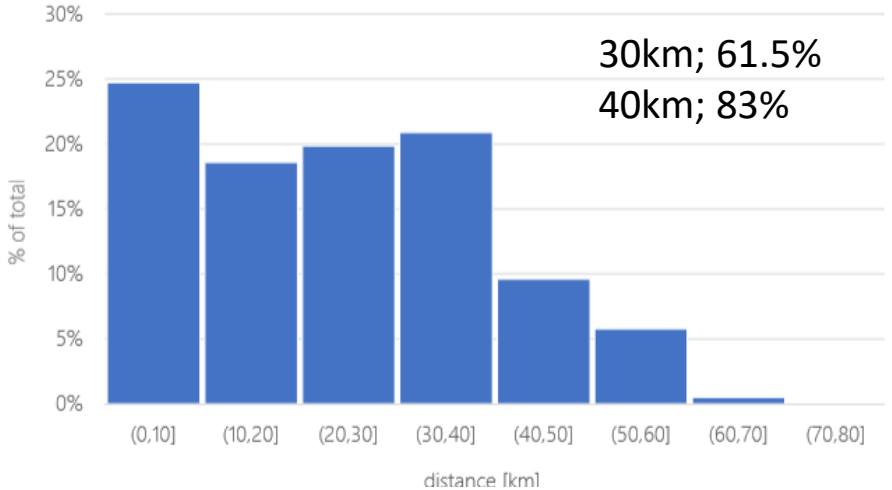
Question: *if we like the standard to be written in more meaningful and compelling manner, how should we handle this situation?*

1. *To relax ER4 Tx launching power and RX Sens., for example by 3dB with 30km, can enable low cost modules because of good yield.*
2. *While 40km module will share the same BOM as 30km and can tolerate higher cost with worse yield.*

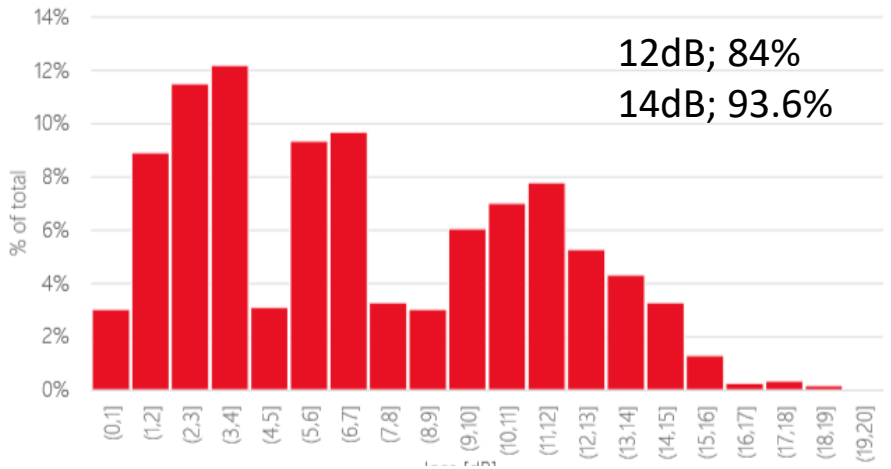
30/40km Fiber distributions (1)

Microsoft examples

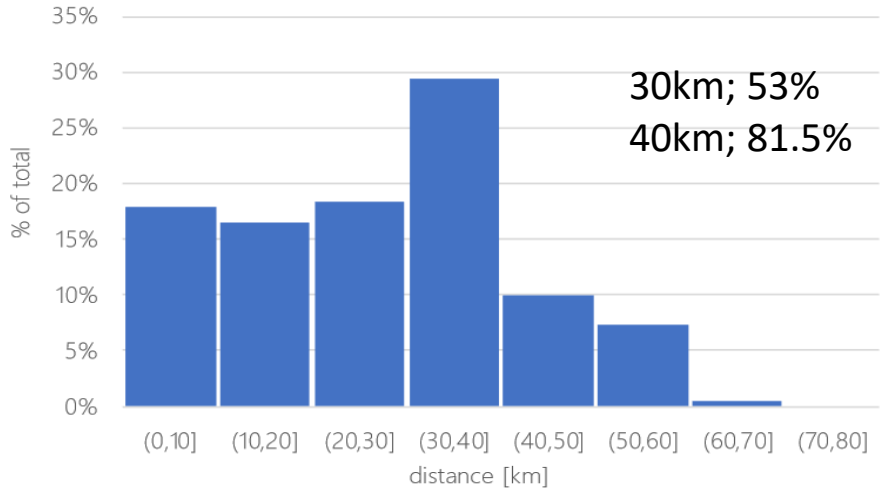
Microsoft span data 3-4-2019

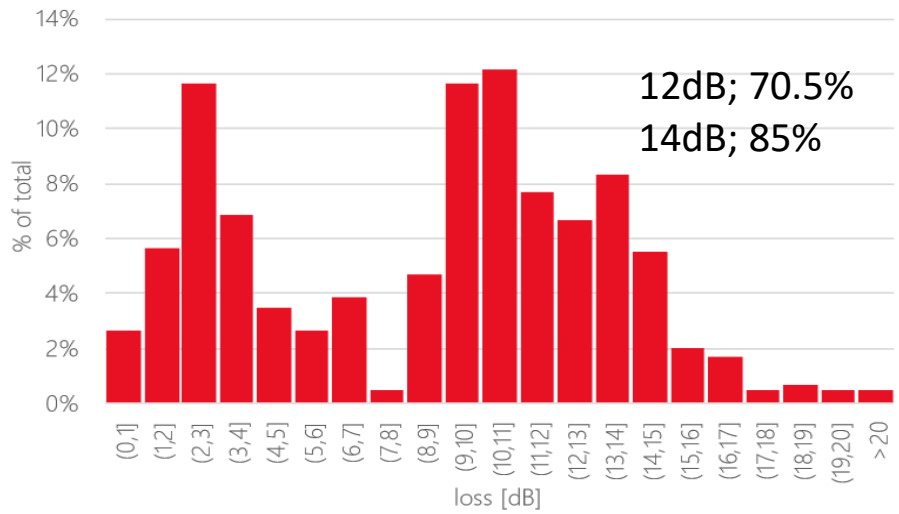


Loss at C band



Microsoft DCI fiber plant distance and loss distributions as of 03/2018





Source: Microsoft

30/40km Fiber distributions (2)

Cable MSO example

MSO Optical Distance Survey (from Beyond 10km PHYs MSO Reference Channels)

http://www.ieee802.org/3/B10K/public/18_05/schmitt_b10k_01a_0518.pdf

- Surveyed CableLabs member companies for information on current optical link distances from headend/hub to current fiber node
- 12 cable operators from Europe and North America responded
- Weighted average of survey results based on number of subscribers per operator
  - <30km: 69%
  - <40km: 88%
  - <60km: 94%
  - <80km: 98%
  - <120km: 100%
  - 1 optical Channel: 50%
  - 2 to 15 channels: 37%
  - +16 channels: 13%
- Assume fiber loss 0.25dB/km at 1550nm.
  - Refer to: https://specification-search.cablelabs.com/P2PCO-SP-ARCH

400G ER8 30km Budget Considerations

IEEE fiber loss assumption
1310nm: 0.4dB/km
1550nm: 0.285dB/km

One example on this page

		Unit
Operating Distance	30	km
TxOMAouter（min）	0.9	dBm
TxOMAouter-TDECQmin	-0.5	dBm
ER（min）	6	dB
TDECQ max	3.4	dB
Channel Insertion Loss	15	dB
MPI penalty	0.5	dB
URS@SECQ = 1.4dB	-14.6	dBm
URS@SECQ = 3.4dB		dBm
URS@SECQ = 2dB		dBm
)MAouter sens-SECQ=1.4dB		dBm

Key questions to answer:

1) *The insertion loss of 15dB is already budgeted as worst-case for 30km.*
2) *Can we like the extra 3dB to distribute among Tx/Rx for 30km ?*
3) *Similarly how do we like the engineered link to be handled for 40km?*

Comments #38, #39 on D2.0 for 200G/400G ER4/8

Cl 122 SC 122.7.1 table 122-9 P 43 L 26 # 38

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Comment Type T *Comment Status* D

Current 100G ER4 deployment in practice use ER lite to guarantee 30km over any deployment fibers and 40km is considered as engineered link, e.g. not guaranteed for worst case deployment fiber from insertion loss perspective. In order to upgrade from 100G-ER4 to 200G-ER4 and 400G-ER8 cost-effectively, we would suggest to also add the 200G-ER4 lite and 400G-ER8 lite catagory (or sub-column). 200G-ER4 lite and 400G-ER8 lite still use the 15dB insertion loss as max. The 3dB extra budget split into two part: allocated 2dB to reduce TxOMA min and 1dB to relax RxOMA max. We will follow up with presenation slides.

SuggestedRemedy

Add 200G-ER4 lite category (or sub-column). Allocate 2dB extra budget to Tx side. Chang TxOMA min from 3.4 to 1.4dB, and change TxOMA-TDECQmin from 2 to 0dBm.

Cl 122 SC 122.7.1 table 122-10 P 44 L 26 # 39

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Comment Type T *Comment Status* D

Current 100G ER4 deployment in practice use ER lite to guarantee 30km over any deployment fibers and 40km is considered as engineered link, e.g. not guaranteed for worst case deployment fiber from insertion loss perspective. In order to upgrade from 100G-ER4 to 200G-ER4 and 400G-ER8 cost-effectively, we would suggest to also add the 200G-ER4 lite and 400G-ER8 lite catagory (or sub-column). 200G-ER4 lite and 400G-ER8 lite still use the 15dB insertion loss as max. The 3dB extra budget split into two part: allocated 2dB to reduce TxOMA min and 1dB to relax RxOMA max. We will follow up with presenation slides.

SuggestedRemedy

Add 400G-ER8 lite category (or sub-column). Allocate 2dB extra budget to Tx side. Chang TxOMA min from 2.4 to 0.4dB, and change TxOMA-TDECQmin from 1 to -1dBm.

Questions/suggestions

- Alternatively, can we consider some “footnote” to guide how TF expect the 3dB additional loss (if not needed) to be distributed among the TX and RX for 30km deployment scenarios? Otherwise how can we help facilitate cost-effective modules (in addition to the multi-vendor interoperability)?
  - Relax the ER4 power budget and RX Sens. facilitate low cost modules.
- 30km are critical market with meaningful fiber coverage which we can’t ignore. Bottom of line, so would TF better clear this out, and won’t leave to let the market decides by itself?
- Following May 9th ad hoc call, the discussion brought up that changing TX and Rx power levels (with referring to 30km or ER-lite) wound actually ask for a new PHY. *Do we have the option (or enough interest) to go back to WG and ask to build consensus for this new PHY / objectives?*

Follow up May 9th ad hoc call:

Action for proposal to add a new PMD and require a review of the CSD documents

- What's the impact on BMP by adding 30km TX and RX?
- What additional data/results are needed?

400 Gb/s Ethernet

- **Support a MAC data rate of 400 Gb/s**
- **Support a BER of better than or equal to 10^-13 at the MAC/PLS service interface (or the frame loss ratio equivalent) for 400 Gb/s**
- **Provide a physical layer specification supporting 400 Gb/s operation over eight wavelengths capable of at least 40 km of SMF**

Summary

- It has been argued that ER applications were not served well by prior IEEE projects.
  - Early adoption was seen in combination with ER lite solutions.
- To add 30km with TX and RX levels, may requires modification to the CSD response to fit within project documentation.
  - Associated with 40km, especially BMP.
  - Determine level of consensus for 30km spec.
- If there is strong ad hoc interest and consensus, proceed to prepare a proposal presentation for the July 802.3 plenary to determine level of interest and consensus among 802.3cn Task Force participants.

Thank YOU