

400GBASE-LR4

Link Budget Proposal

P802.3cu 100 Gb/s and 400 Gb/s over SMF at
100 Gb/s per Wavelength Task Force Ad Hoc

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FINISAR[®]

Introduction

- At the May Interim, there was discussion of alternatives to 400G LR4 spec based on worst case 10km SMF link
 - What's so special about 10km?
http://www.ieee802.org/3/cu/public/May19/cole_3cu_02c_0519.pdf
 - Two SMF Spec Limit Types for 802.3 PMDs Proposal
http://www.ieee802.org/3/cu/public/May19/cole_3cu_01a_0519.pdf
- At the July Plenary, one of the considered paths for moving forward was to reduce the 400G LR4 10km reach objective
- While 10km has some operating advantages, end users are not willing to pay a cost premium for this exact reach over a shorter reach with same link and loss budget
- The first version of this presentation was discussed on the August Ad Hoc call
http://www.ieee802.org/3/cu/public/cu_adhoc/cu_archive/cole_3cu_adhoc_082119.pdf

Network Operator Support

- Weiqiang Cheng, China Mobile
- Junjie Li, China Telecom
Need similar link budget as LR8 and shorter reach is acceptable
- Glenn Wellbrock, Verizon
We prefer a lower-cost, lower-reach version that leverages FR4 volumes. The loss budget is important but not the dispersion budget because we would rarely if ever use this optic for inter-office connections.
- Sam Sambasivan, ATT
Need is for backwards compatibility between 400G LR4 and 400G FR4 to leverage investment in 400G FR4.
- Ralf-Peter Braun, Deutsche Telekom
Reduced-reach high-volume cheaper device is better than more expensive 10 km device because in a Telco environment exact reach does not make a big difference

Cost is King

- CWDM grid has technical cost advantages:
 - No TEC, and associated simpler assembly techniques
 - Simpler WDM filters
- However, main cost drivers are:
 - Volume
 - Manufacturing margin
- 400G FR4 in 3+ years is expected to be a high volume interface in the cloud datacenter
- Using TF contributions, worst case 10km SMF link CWDM4 spec does not have good, if any, manufacturing margin
- Ideal spec leverages the FR4 volume and has good manufacturing margin (multiple yield sigmas)

100GBASE-LR4 Link Budget Proposal

Illustrative Link Power Budget		
Description	400GBASE-LR4	Unit
Power budget (for max TDECQ)	10.5	dB
Operating distance	6	km
Channel insertion Loss	5.0	dB
Allocation for penalties (for max TDECQ)	4.2	dB
Additional insertion loss allowed	1.3	dB

Leaves unaddressed the problem identified by Brian of how to prevent bad transmitters (excessive transmitter penalty) for middle wavelengths

L Suffix 802.3 Reach, Budget Comparisons

Code	Illustrative Power Budget dB	Total Channel Insertion Loss dB	Operating Distance km
1000 LX	8.0	4.7	5
1000 LX10	10.5	8.0	10
10G LR	9.4	6.2	10
40G LR4	9.3	6.7	10
100G LR4	8.5	6.3	10
200G LR4	10.2	6.3	10
400G LR8	10.1	6.3	10
Proposed 400G LR4	10.5	6.3	6

- Long Wavelength Serial, i.e. O-band Serial
- Serial no longer applies to WDM PMDs
- LR common misuse is Long Reach

S Suffix 802.3 Reach Comparisons

Code	Minimum modal bandwidth @ 850 nm (MHz·km)	Operating range max (meters)
1000BASE-SX	160, 200	220, 275
	400, 500	500, 550
10GBASE-SR	160 / 200	26 / 33
	400 / 500	66 / 82
	2000	300
40GBASE-SR4	2000	100
100GBASE-SR10	4700	150
100GBASE-SR4	2000	70
400GBASE-SR16		
50GBASE-SR	4700	100
100GBASE-SR2		
200GBASE-SR4		

- Short Wavelength Serial, originally 850nm Serial
- Serial no longer applies to WDM PMDs
- SR common misuse is Short Reach

E, C, R Suffix 802.3 Use

- E suffix
 - Extended Long Wavelength Serial, originally C-band Serial
 - Serial no longer applies to WDM PMDs
 - Used for 30km and 40km reach, in C-band and O-band
 - ER common misuse is Extended Reach
- C suffix
 - Short-haul Copper, i.e. copper cable
 - Used for 2m to 25m reach, function of rate, coding, cable construction, and other parameters
- K suffix
 - Backplane Copper, i.e. PCB copper traces
 - Up to 1m reach

L, S, VSR ITU-T USE

- G.959.1 application codes:
 - L indicates long haul (22dB span attenuation)
 - S indicates short haul (11dB span attenuation)
 - Reach is function of budget, fiber type and rate
- G.695 application codes:
 - L indicates long-haul span distance
 - S indicates short-haul span distance
 - Reach is function of budget, fiber type and rate
- G.693 application codes:
 - VSR600, VSR1000 and VSR2000 indicate target distances of 0.6 km, 1 km and 2 km, respectively
 - Attenuation categories are 4 dB, 6 dB, 12 dB, 16dB
 - Reach is function of budget, fiber type and rate

L Suffix Use Extension

- There will be 200 Gb/s and 400 Gb/s per wavelength specs. (hopefully we will write them when industry is ready)
- It is unreasonable to expect that regardless of technology break-points, the L Suffix is artificially tied to just 10km reach
- 802.3cu is a good place to extend the use of L Suffix to include reaches other than 10km, and stop the proliferation of arbitrary letters tied to specific reaches
- No other standard ties a Suffix to just one reach
- We don't have to go back and fix other standard names
- This will additionally provide guidance to industry to replace the patch work of +, -, lite, and other modifiers to indicate different reaches

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Thank You