Improving the extinction ratio specs

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Introduction

- To allow a variety of transmitter technologies for good performance, low power and cost, the extinction ratio limits should be reduced to as low as reasonable while protecting the link and the receiver
  - See references slide for previous presentations
- In May, comments bs 45, 52, 19 and 53 were accepted in principle, cd comments 44 and 47 were invited for resubmission. See D2.0 comments 37, 153, 59, 129, 44 and 43
- The situation is now:

Project	bs	cd	bs	cd	bs	cd	bs
PMD	200G-DR4	50G-FR	200G-FR4, 400G-FR8	50G-LR	200G-LR4, 400G-LR8	100G-DR	400G-DR4
Ext R (dB)	3.5	4.5	3.5	4.5	3.5	5	3.5

- This presentation shows how to apply consistent limits for the three SMF PMD types in P802.3cd

Motivation

- Want to avoid excluding or unnecessarily burdening the transmitter
  - Directly modulated lasers (DML)
    - Well-known benefit of lower extinction ratio: less distortion in the eye
  - Electro-absorption modulators (EAM)
    - e.g. silicon photonics EAM
    - Transmitter can be shorter (faster, e.g. 10 GHz more bandwidth) and/or driven with less volts (power, cost), and deliver more output OMA
    - There are benefits for any EAM type e.g. better TDECQ

Consequential changes

- Multi-path interference (MPI) is affected by the extinction ratio
- Reducing the extinction ratio doesn't hurt a PAM4 link budget much, because the extinction ratio is low anyway for the upper eye
- But the small difference can be quantified...
  - http://ieee802.org/3/bs/public/adhoc/smf/16_01_07/king_01a_0116_smf.pdf
  - http://ieee802.org/3/bs/public/adhoc/smf/16_01_07/king_02a_0116_smf.7z
  - http://ieee802.org/3/bs/public/adhoc/smf/17_05_16/anslow_01_0517_smf.pdf
  - http://ieee802.org/3/cd/public/May17/king_3cd_01_0517.pdf
  - http://ieee802.org/3/cd/public/May17/anslow_3cd_01_0517.pdf
- And budgeted for

50GBASE-FR and 50GBASE-LR

- We need 0.1 dB more optical power budget
  - For additional MPI
- These PMDs have enough margin that the receiver sensitivity can be improved by 0.1 dB without affecting the cost
  - stassar_061417_3cd_adhoc-v2.pdf
  - stassar_3cd_01_0717.pdf
- Comments 37 and 153 propose this, with the implementation shown in the next two slides

Detailed changes to Clause 139 for 50GBASE-FR and 50GBASE-LR 1 of 2

- Table 139-6
  - Change Extinction ratio (min) from 4.5 dB to 3.5 dB
- Table 139-7
  - Change Receiver sensitivity (OMA_{outer}) (max):
    - From -7.3 dBm to -7.4 dBm for 50GBASE-FR
    - From -8.8 dBm to -8.9 dBm for 50GBASE-LR
  - Change Stressed receiver sensitivity (OMA_{outer}) (max):
    - From -5 dBm to -5.1 dBm for 50GBASE-FR
    - From -6.3 dBm to -6.4 dBm for 50GBASE-LR

Consequential changes to reflections in cable plant, Clause 139 – FR, LR 2 of 2

Table 139-14 for 50GBASE-FR or 50GBASE-LR (to align with Table 122-19, for 200GBASE-FR4, 200GBASE-LR4, 400GBASE-FR8, and 400GBASE-LR8)

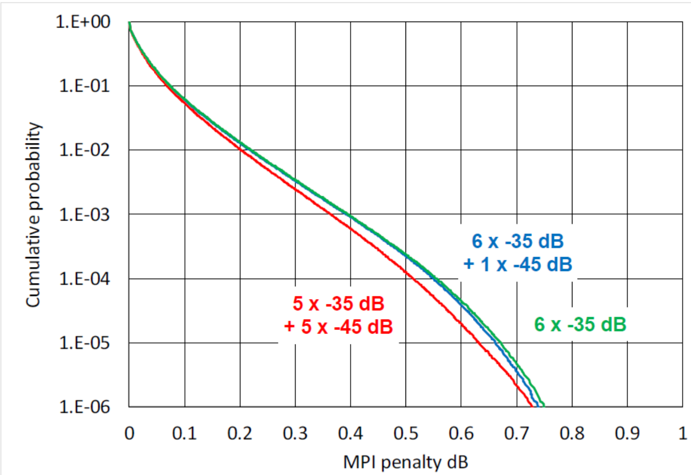
Number of discrete reflectances above –55 dB	Maximum value for each discrete reflectance	
	50GBASE-FR (as 200GBASE-FR4 or 400GBASE-FR8)	50GBASE-LR (as 200GBASE-LR4 or 400GBASE-LR8)
1	–25 dB	–22 dB
2	–31 dB	–29 dB
4	–35 dB	–33 dB
6	–38 dB	–35 dB
8	~~–39~~ –40 dB	–37 dB
10	~~–40~~ –41 dB	~~–38~~ –39 dB

100GBASE-DR

- Comments 44, 129 and 59 propose an extinction ratio limit of 3.5 dB
- We need 0.3 dB more optical power budget
  - anslow_3cd_01_0517.pdf
- So as not to inconvenience transmitters that do not take advantage of a lower extinction ratio limit, nor burden any receivers,
- Provide two TDECQ limits for two extinction ratio ranges
- Comments 44, and 129 propose this
  - see next slides

Is another 0.3 dB MPI OK?

Worst three curves with ER = 3.5 dB



From [anslow_3cd_01_0517.pdf]()

- Max TDECQ + MPI would be 2.5+0.75 = 3.25 dB
- Since the MPI discussions of some time ago, we have this calculation for better (lower probability than before, showing the curve bending down – reassuring
- Applying the MPI method to a PAM2 PMD such as 10GBASE-LR or 25GBASE-LR gives predictions that seem pessimistic

- Compare 100GBASE-SR4
  - Transmitter and dispersion eye closure (TDEC) 4.3 dB
  - Allocation for penalties (for max TDEC) 6.3 dB
- Or 10GBASE-SR
  - Transmitter and dispersion penalty 3.9 dB
  - Allocation for penalties up to 5.1 dB
- As the ability of a receiver to handle distortion is not expected to be worse for long wavelength than short, it seems this is OK

Implementation for 100GBASE-DR 1/3

Table 140–6—100GBASE-DR transmit characteristics

Description	Value	Unit
Signaling rate (range)	53.125 ± 100 ppm	GBd
Modulation format	PAM4	—
Wavelength (range)	1304.5 to 1317.5	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Average launch power (max)	4	dBm
Average launch power[a] (min)	–2.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (max)	4.2	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (min)[b]	–0.3	dBm
Launch power in OMA_{outer} minus TDECQ (min)		
for extinction ratio ≥ 5 dB	–1.3	dBm
for extinction ratio < 5 dB	–1	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	2.5	dB
Average launch power of OFF transmitter (max)	–15	dBm
Extinction ratio (min)	~~5~~ 3.5	dB
$RIN_{15.5}OMA$ (max)	–136	dB/Hz
Optical return loss tolerance (max)	15.5	dB
Transmitter reflectance[c] (max)	–26	dB

[a]Average launch power (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.
[b]Even if the TDECQ < 1 dB, the OMA_{outer} (min) must exceed ~~these values~~. this value.
[c]Transmitter reflectance is defined looking into the transmitter.
for an extinction ratio of ≥ 4.5 dB or TDECQ < 0.7 dB for an extinction ratio of < 4.5 dB

This the proposal in comment 129

See slide 13 for the proposal in comment 44

Implementation for 100GBASE-DR 2/3

Table 140–8—100GBASE-DR illustrative link power budget

Parameter	Value	Unit
Power budget (for max TDECQ)		
for extinction ratio ≥ 5 dB	5.6	dBm
for extinction ratio < 5 dB	5.9	dBm
Operating distance	500	m
Channel insertion loss[a]	See 140.9	dB
Maximum discrete reflectance	–35	dB
Allocation for penalties[b] (for max TDECQ)		
for extinction ratio ≥ 5 dB	5.6 minus max channel insertion loss per Table 140–12	dBm
for extinction ratio < 5 dB	5.9 minus max channel insertion loss per Table 140–12	dBm
Additional insertion loss allowed	0	dB

[a]The channel insertion loss is calculated using the maximum distance specified in Table 140–5 and cabled optical fiber attenuation of 0.5 dB/km at 1304.5 nm plus an allocation for connection and splice loss given in 140.10.2.1.
[b]Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

Comments 129 and 44 agree on this

Consequential changes to reflections in cable plant – 100GBASE-DR 3/3

Following anslow_3cd_01_0517.pdf

Table 140–12, Maximum channel insertion loss versus number of discrete reflectances

Maximum channel insertion loss (dB)		**Number of discrete reflectances > –55 dB and ≤ –45 dB**								
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of discrete reflectances > –45 dB and ≤ –35 dB	**0**	3	3	3	3	3	3	3	3	3
	1	3	3	3	3	3	3	3	3	3
	2	3	3	3	2.9	2.9	2.9	2.9	2.9	2.9
	3	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	—a
	4	2.8	2.8	2.8	2.8	2.7	2.7	2.7	—a	—a
	5	2.8	2.8	2.7	2.7	2.7	2.6	—a	—a	—a
	6	~~2.7~~ 2.6	2.6	—a	—a	—a	—a	—a	—a	—a

a The indicated combination of reflectances does not provide a supported maximum channel insertion loss.

Comments 129 and 44 agree on this. Comment 43 says this change should be made anyway

100GBASE-DR 1/3 alternative

Table 140–6—100GBASE-DR transmit characteristics

Description	Value	Unit
Signaling rate (range)	53.125 ± 100 ppm	GBd
Modulation format	PAM4	—
Wavelength (range)	1304.5 to 1317.5	nm
Side-mode suppression ratio (SMSR), (min)	30	dB
Average launch power (max)	4	dBm
Average launch power[a] (min)	–2.4	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (max)	4.2	dBm
Outer Optical Modulation Amplitude (OMA_{outer}) (min)[b]		dBm
for extinction ratio ≥ 5 dB	–0.3	dBm
for extinction ratio < 5 dB	0	dBm
Launch power in OMA_{outer} minus TDECQ (min)		
for extinction ratio ≥ 5 dB	–1.3	dBm
for extinction ratio < 5 dB	–1	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	2.5	dB
Average launch power of OFF transmitter (max)	–15	dBm
Extinction ratio (min)	5	dB
$RIN_{15.5}OMA$ (max)	–136	dB/Hz
Optical return loss tolerance (max)	15.5	dB
Transmitter reflectance[c] (max)	–26	dB

[a]Average launch power (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.
[b]Even if the TDECQ < 1 dB, the OMA_{outer} (min) must exceed these values.
[c]Transmitter reflectance is defined looking into the transmitter.

This the proposal in comment 44

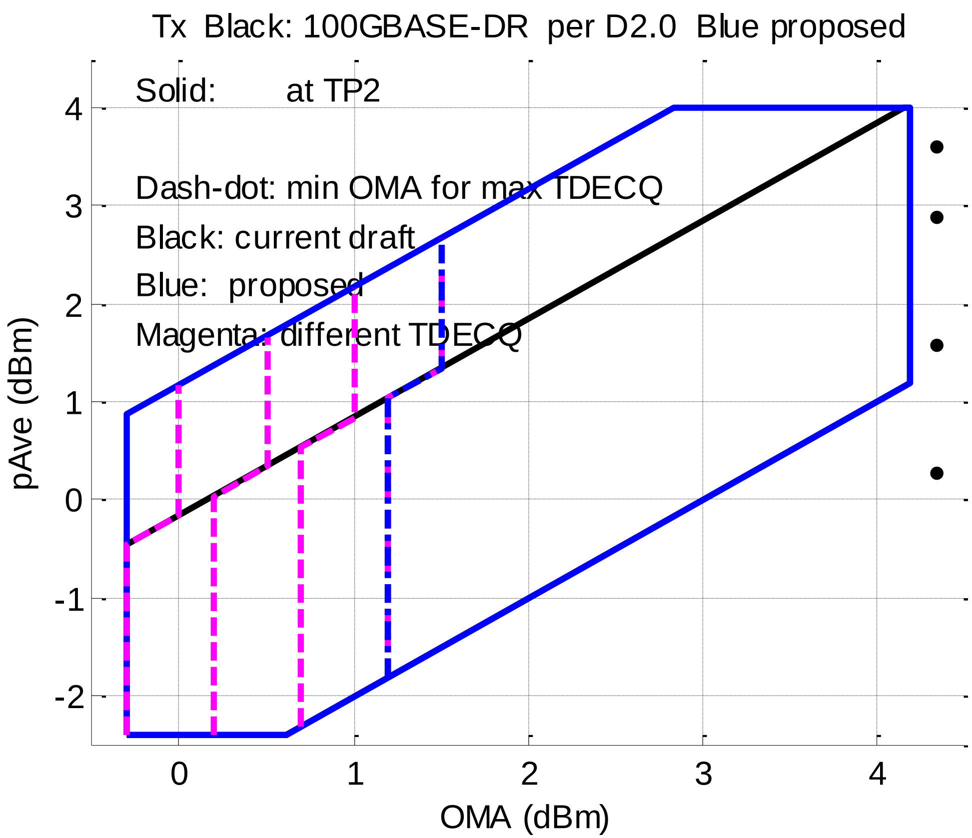
See slide 10 for the proposal in comment 129

Is it worth modifying the OMA min?

References

- http://ieee802.org/3/bs/public/adhoc/smf/17_04_25/dawe_01_0417_smf.pdf
- http://ieee802.org/3/cd/public/adhoc/archive/dawe_042617_3cd_adhoc-v3.pdf
- http://ieee802.org/3/cd/public/adhoc/archive/king_051017_3cd_adhoc_03.pdf
- http://ieee802.org/3/cd/public/adhoc/archive/dawe_051017_3cd_adhoc.pdf
- http://ieee802.org/3/bs/public/adhoc/smf/17_05_16/anslow_01_0517_smf.pdf
- http://ieee802.org/3/bs/public/adhoc/smf/17_05_16/dawe_01_0517_smf.pdf
- http://ieee802.org/3/cd/public/May17/king_3cd_01_0517.pdf
- http://ieee802.org/3/cd/public/May17/anslow_3cd_01_0517.pdf
- http://ieee802.org/3/cd/public/May17/dawe_3cd_01_0517.pdf
- http://ieee802.org/3/bs/public/17_05/dawe_3bs_01_0517.pdf
- P802.3bs Draft D3.2
- http://ieee802.org/3/cd/public/adhoc/archive/stassar_061417_3cd_adhoc-v2.pdf
- http://ieee802.org/3/bs/public/May17/stassar_3cd_01_0717.pdf

100GBASE-DR transmitter setup map



- A single Tx waveform measurement is used to find TDECQ, OMA, mean power, and extinction ratio

- Black polygon (partly hidden under blue one): Tx spec in D1.3, with 5 dB min. extinction ratio
- Blue polygon: proposed, 3.5 dB
- With 0.3 dB more OMA-TDECQ below 5 dB
- Channel, connectors and receivers don't change
- Alternatives include:
  - Improve Rx sensitivity, and stressed sensitivity, and increase budget, by 0.3 dB (for any extinction ratio)
    - Not favoured from receiver's point of view
  - Tighten Tx minimum OMA-TDECQ, OMA and minimum average power, and increase budget, by 0.3 dB for any extinction ratio
    - Not favoured from the high extinction ratio transmitter's point of view
  - Include MPI in TDECQ
    - Would need to input a reflections parameter (a number) into TDECQ as well as chromatic dispersion and reflection (real fibre and components)

Conclusion

- Looking forward to reduced cost and power,
- A lower extinction ratio limit should and can be applied to all SMF PMDs in P802.3cd
  - Aligning with P802.3bs
  - This presentation gives the details