Improved extinction ratio specifications

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Supporters

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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
  - In March, comments bs 127,148 and 151, and cd 138, 200, 139 and 211, proposed 3 dB or 3.5 dB ER and were referred for further study and consensus building. See D1.3 comments 44, 47
- Recent presentations in P802.3cd ad hoc and P802.3bs SMF ad hoc explained the motivation, quantified the consequences, and progressed the consensus building
- 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
- And presentation to March P802.3bs meeting
- This presentation shows to do this for the three SMF PMD types in P802.3cd

Motivation

- Want to avoid excluding some transmitter technologies from future implementations
  - 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

Limitations

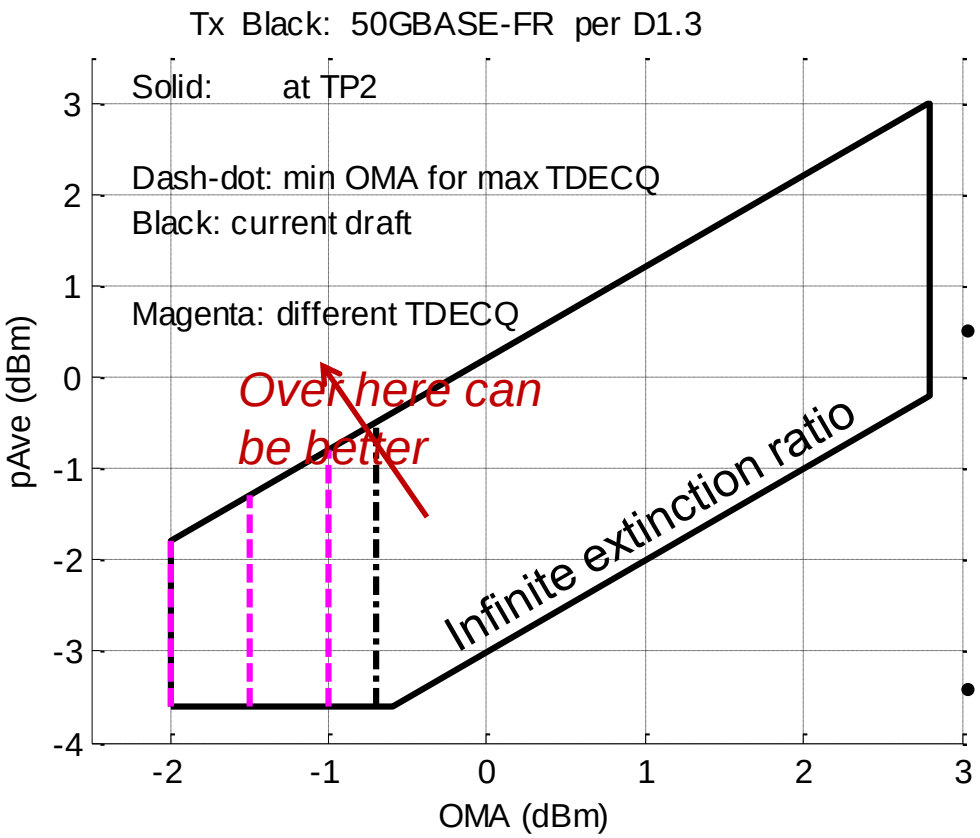
- Multi-path interference (MPI) is affected by the extinction ratio
- Reducing the extinction ratio doesn't hurt a PAM4 link budget much, because the extinction ratio is low anyway for the upper eye
- But the small difference can be quantified...

  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

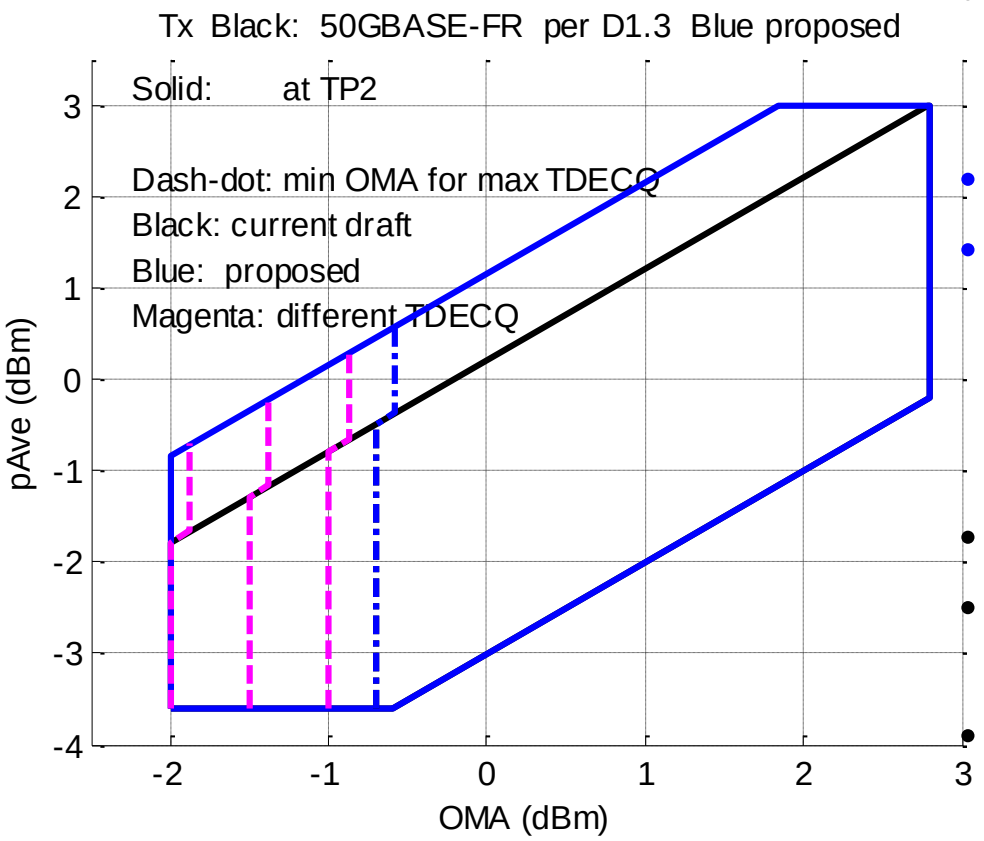
  http://ieee802.org/3/bs/public/adhoc/smf/17_05_16/anslow_01_0517_smf.pdf
- And budgeted for

50GBASE-FR transmitter setup map



- Black polygon: Tx spec in D1.3, with 4.5 dB min. extinction ratio
- 50GBASE-FR, 200GBASE-FR4 and 400GBASE-FR8 have the same extinction ratio, transmitter, receiver and cable plant reflectances, and channel insertion loss
- So the MPI characteristics are very similar
- A single Tx waveform measurement is used to find TDECQ, OMA, mean power, and extinction ratio

50GBASE-FR transmitter setup map: proposal



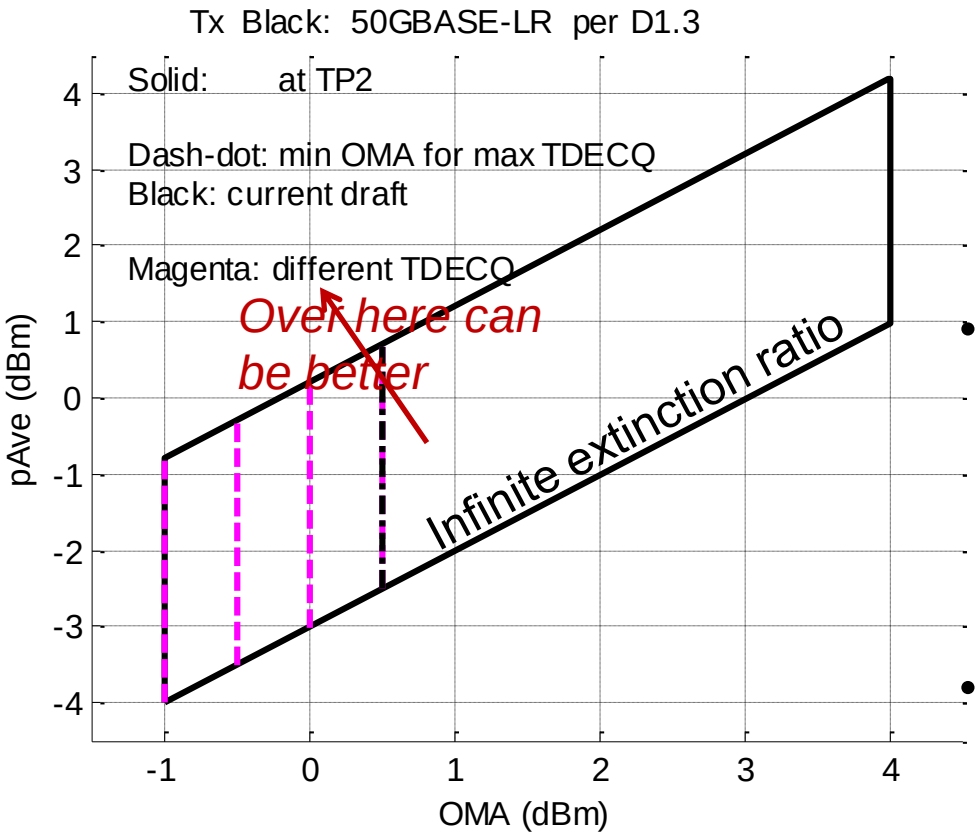
- A single Tx waveform measurement is used to find TDECQ, OMA, mean power, and extinction ratio

- Black polygon (partly hidden under blue one): Tx spec in D1.3, with 4.5 dB min. extinction ratio
- Blue polygon: proposal: 3.5 dB
- And 0.1 dB more OMA-TDECQ below 4.5 dB
  - For extra multipath interference penalty
  - anslow_01_0517_smf slides 7-10
- Tx spec becomes easier
- Channel, connectors and receivers don't change
- **Other options include:**
  - Improve Rx sensitivity, and stressed sensitivity, and increase budget, by 0.1 dB (for any extinction ratio)
  - Tighten Tx minimum OMA-TDECQ, OMA and minimum average power, and increase budget, by 0.1 dB for any extinction ratio
  - Include MPI in TDECQ

50GBASE-**F**R and 50GBASE-**L**R channel discrete reflectances

- Table 139–14, Maximum value of each discrete reflectance, can be re-optimised, about the pivot of **4** (50GBASE-**F**R) or 6 (50GBASE-**L**R) connectors at -35 dB. See later slide.

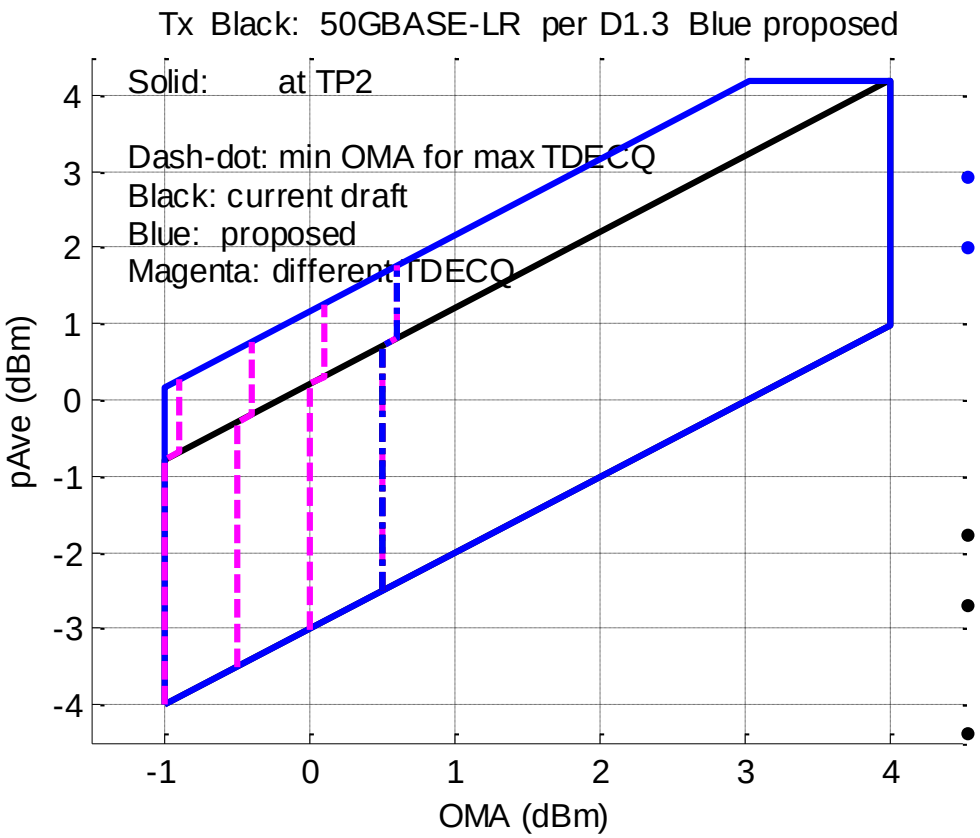
50GBASE-LR transmitter setup map



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

- Black polygon: Tx spec in D1.3, with 4.5 dB min. extinction ratio
- 50GBASE-LR, 200GBASE-LR4 and 400GBASE-LR8 have the same extinction ratio, transmitter, receiver and cable plant reflectances, and channel insertion loss
- So the MPI characteristics are very similar

50GBASE-LR transmitter setup map: proposal



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

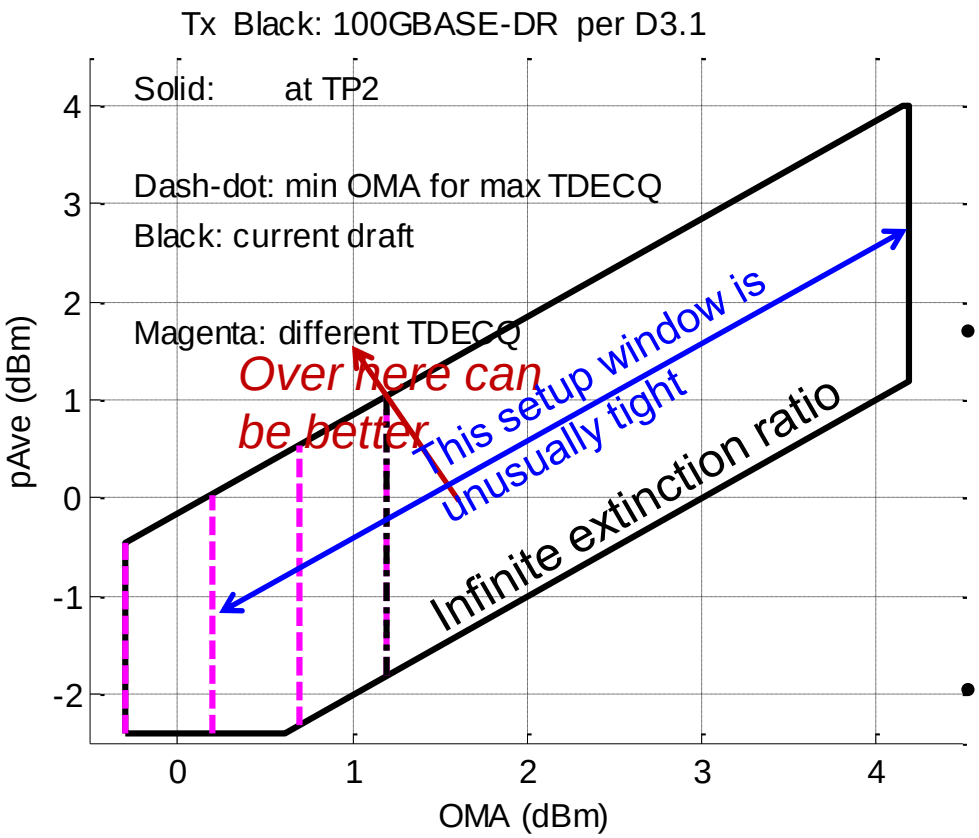
- Black polygon (partly hidden under blue one): Tx spec in D1.3, with 4.5 dB min. extinction ratio
- Blue polygon: proposal: 3.5 dB
- And 0.1 dB more OMA-TDECQ below 4.5 dB
  - For extra multipath interference penalty
  - anslow_01_0517_smf slides 3-6
- Tx spec becomes easier
- Channel, connectors and receivers don't change
- **Other options include:**
  - Improve Rx sensitivity, and stressed sensitivity, and increase budget, by 0.1 dB (for any extinction ratio)
  - Tighten Tx minimum OMA-TDECQ, OMA and minimum average power, and increase budget, by 0.1 dB for any extinction ratio
  - Include MPI in TDECQ

Consequential changes to reflections in cable plant – FR, LR

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

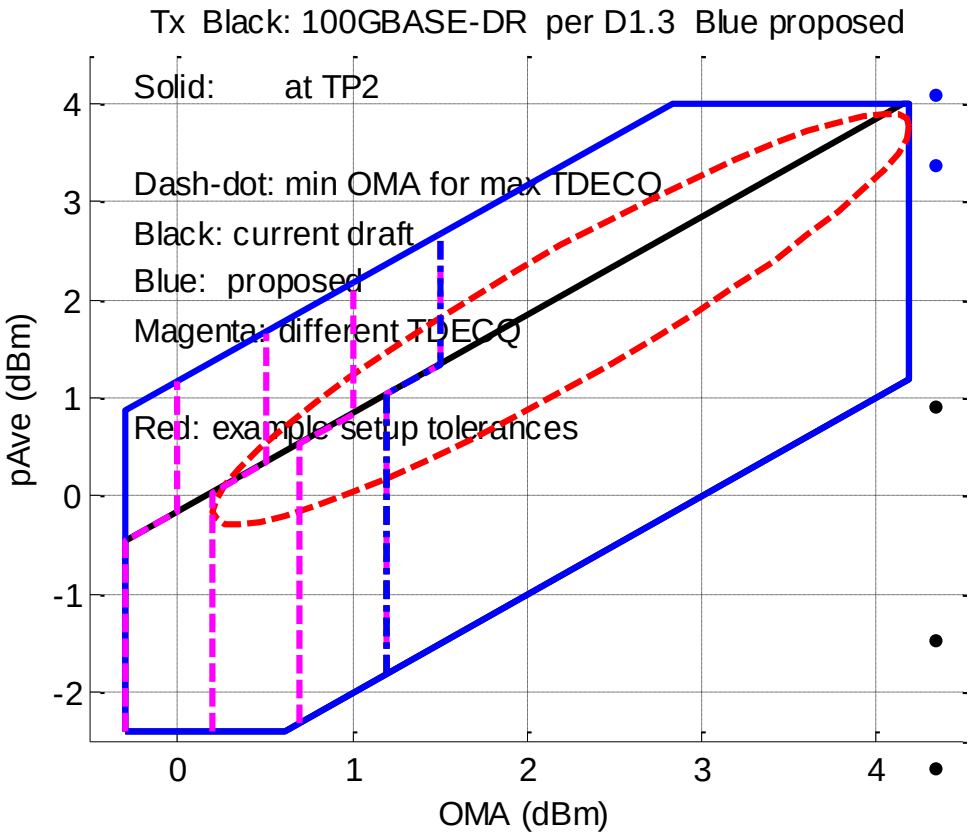
Number of discrete reflectances above –55 dB	Maximum value for each discrete reflectance	
	50GBASE-FR (or 200GBASE-FR4 or 400GBASE-FR8)	50GBASE-LR (or 200GBASE-LR4 or 400GBASE-LR8)
1	–25 dB	–22 dB
2	–31 dB	–29 dB
4	–35 dB	–33 dB
6	–38 dB	–35 dB
8	~~–39~~ –40 dB	–37 dB
10	~~–40~~ –41 dB	~~–38~~ –39 dB

100GBASE-DR transmitter setup map



- Black polygon: Tx spec in D1.3, with 5 dB min. extinction ratio
- 100GBASE-DR has the same extinction ratio, and transmitter and receiver reflectances, as 400GBASE-DR4, but different channel insertion loss and reflectances
- So the MPI characteristics are different
- A single Tx waveform measurement is used to find TDECQ, OMA, mean power, and extinction ratio

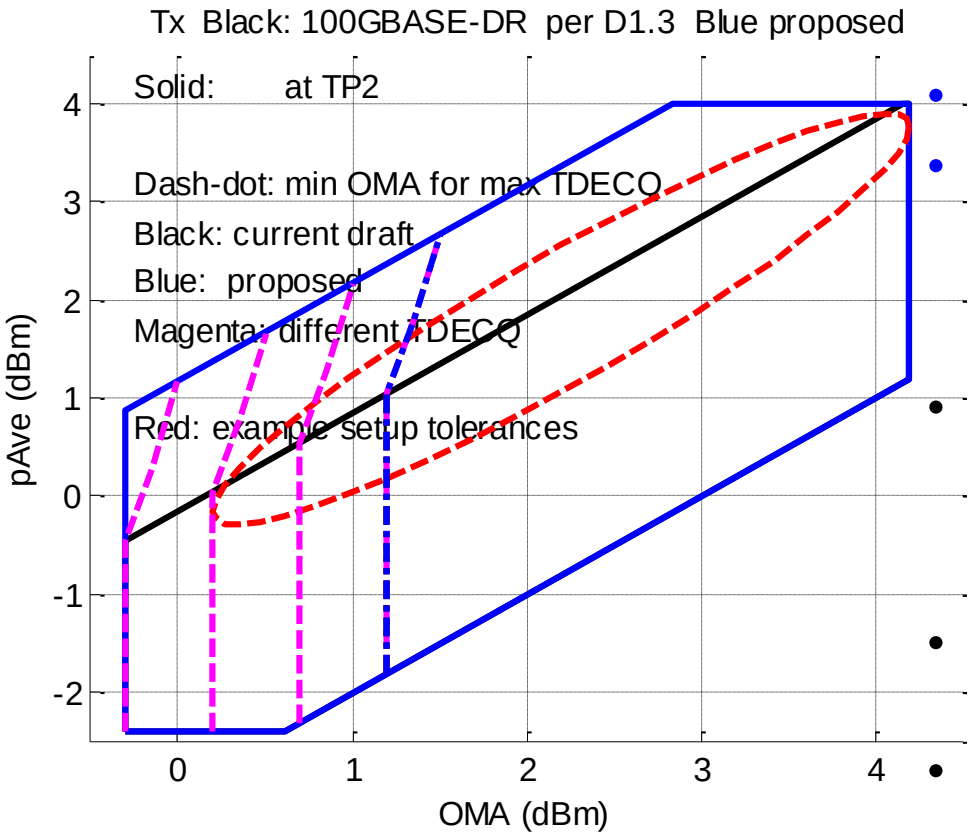
100GBASE-DR transmitter setup map: proposal A



- 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 4.5 dB min. extinction ratio
- Blue polygon: proposal: 3.5 dB
- And 0.3 dB more OMA-TDECQ below 4.5 dB
  - For extra multipath interference penalty
  - anslow_01_0517_smf slides 3-6
- Tx spec becomes easier apart from tolerancing
  - Needs very good power control (output coupling, tracking, ageing)
- Channel, connectors and receivers don't change
- **Other options include:**
  - Improve Rx sensitivity, and stressed sensitivity, and increase budget, by 0.1 dB (for any extinction ratio)
  - Tighten Tx minimum OMA-TDECQ, OMA and minimum average power, and increase budget, by 0.1 dB for any extinction ratio
  - Include MPI in TDECQ

100GBASE-DR transmitter setup map: proposal B



- 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 4.5 dB min. extinction ratio
- Blue polygon: proposal: 3.5 dB
- And **up to** 0.3 dB more OMA-TDECQ below 4.5 dB
  - For extra multipath interference penalty
  - anslow_01_0517_smf slides 3-6
- Tx spec becomes easier
  - **Gradual increase** with extinction ratio avoids re-entrant corner
- Channel, connectors and receivers don't change
- **Other options include:**
  - Improve Rx sensitivity, and stressed sensitivity, and increase budget, by 0.1 dB (for any extinction ratio)
  - Tighten Tx minimum OMA-TDECQ, OMA and minimum average power, and increase budget, by 0.1 dB for any extinction ratio
  - Include MPI in TDECQ

Option A

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)		
Extinction ratio ≥ 5 dB	–1.3	dBm
3.5 dB < 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.

is less than 1 dB or 0.9 dB depending in the extinction ratio

or

is less than 1 dB for a transmitter with an extinction ratio greater or equal to 4.5 dB or less than 0.9 dB for a transmitter with an extinction ratio less than 4.5 dB

or

is small

Option B

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)		
ER ≥ 5 dB	–1.3	dBm
3.5 dB < ER < 5 dB	–0.3 – 0.2ER [d]	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	2.5	dB
Average launch power of OFF transmitter (max)	–15	dBm
Extinction ratio (ER) (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.

is small

d Where ER is the extinction ratio in dB

[Notes c and d would be reversed]

Consequential changes to reflections in cable plant – DR?

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	—a	—a	—a	—a	—a	—a	—a

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

Any changes to this table? See king_051017_3cd_adhoc_03 To be confirmed

Consequential change to budgets – all three PMDs

- In Table 139–8, 50GBASE-FR and 50GBASE-LR illustrative link power budgets
  - Either: quote budget for maximum TDECQ and 4.5 dB extinction ratio as appropriate, leave numbers unchanged
  - Or: Add 0.1 dB to each entry in the budget and allocation for penalties rows
- In Table 140–8, 100GBASE-DR illustrative link power budget
  - Either: quote budget for maximum TDECQ and 5 dB extinction ratio as appropriate, leave numbers unchanged
  - Or: Add 0.3 dB to the budget and allocation for penalties
- The second way seems cleaner

Conclusion

- A lower extinction ratio limit should and can be applied to all SMF PMDs in P802.3bs
  - This presentation gives the details

- Looking forward to reduced cost and power