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 D3.1 comments 45, 52, 19, 53
- 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
- This presentation shows to do this for the six SMF PMD types in P802.3bs

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

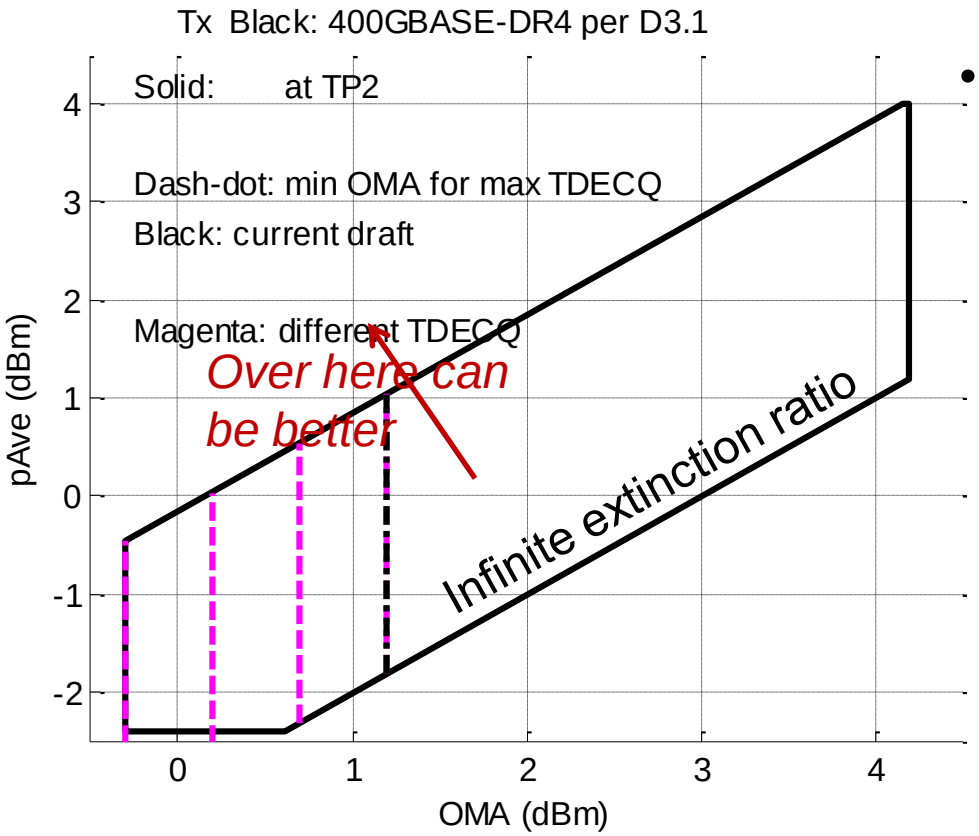
  http://ieee802.org/3/bs/public/adhoc/smf/17_05_16/anslow_01_0517_smf.pdf
- And budgeted for

200GBASE-DR4 and 400GBASE-DR4

- Because 200GBASE-DR4 and 400GBASE-DR4 work over parallel-fibre cable plant, which has low reflection connectors, the expected multipath interference penalty is so small that the budget is unchanged
  - For 200GBASE-DR4, Table 121–15, Maximum value of each discrete reflectance
  - For 400GBASE-DR4, Table 124–13, Maximum value of each discrete reflectance
  - Both say:

Number of discrete reflectances above –55 dB	Maximum value for each discrete reflectance
1	–37 dB
2	–42 dB
4	–45 dB
6	–47 dB
8	–48 dB
10	–49 dB

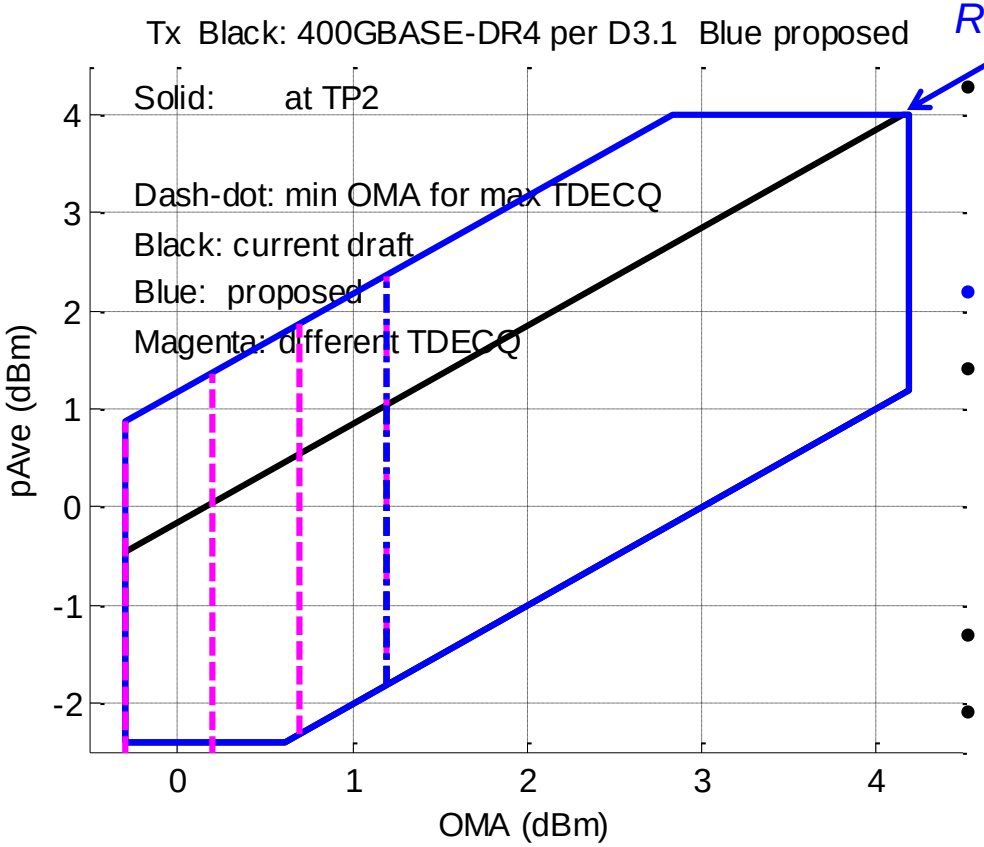
Transmitter setup map: 400GBASE-DR4



- Black polygon: Tx spec in D3.1, with 5 dB min. extinction ratio

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

400GBASE-DR4 setup map: proposal

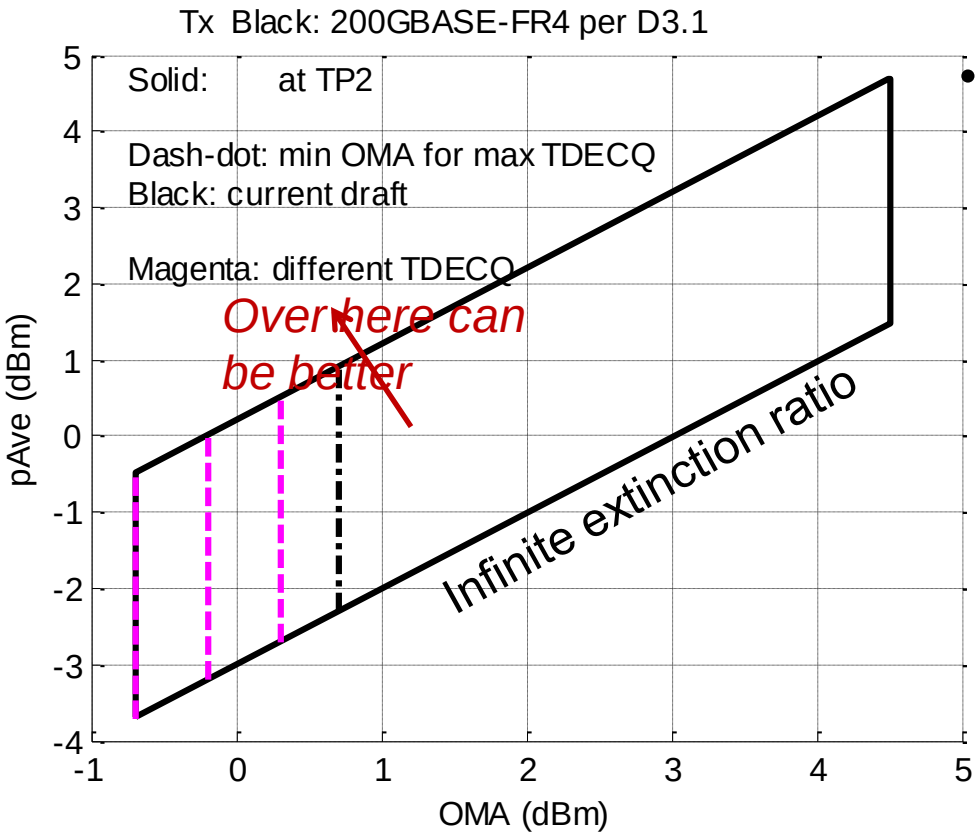


Receiver overload is unchanged for all PMDs

- Black polygon (partly hidden under blue one): Tx spec in D3.1, with 5 dB min. extinction ratio
- Blue polygon: proposal: 3.5 dB
- The expected multipath interference penalty is so small that the budget is unchanged
  - anslow_01_0517_smf slides 11-13
- Tx spec becomes easier
- Channel, connectors and receivers don't change

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

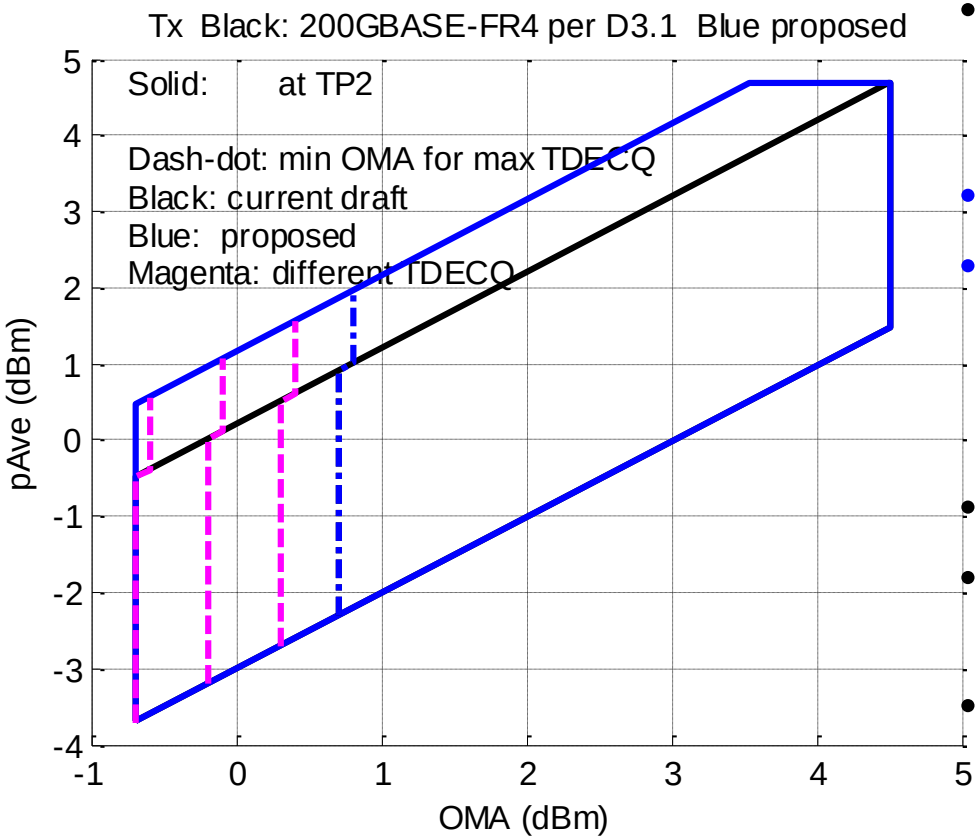
Transmitter setup map: 200GBASE-FR4



- Black polygon: Tx spec in D3.1, with 4.5 dB min. extinction ratio

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

200GBASE-FR4 setup map: proposal



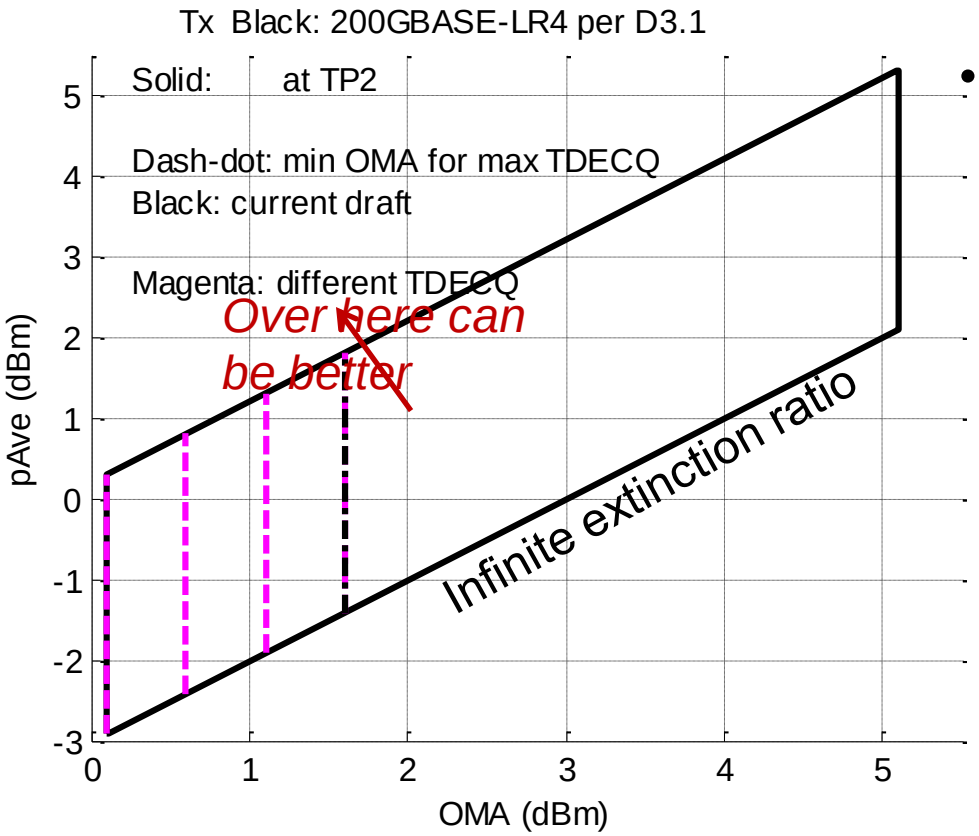
- A single Tx waveform measurement is used to find TDECQ, OMA, mean power, and extinction ratio

- Black polygon (partly hidden under blue one): Tx spec in D3.1, 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

200GBASE-FR4 and 400GBASE-FR8

- The extinction ratio and MPI considerations are the same for 200GBASE-FR4 and 400GBASE-FR8: same extinction ratio limit and discrete reflectance (Table 122–19)
  - This table can be re-optimised, about the pivot of **4** connectors at -35 dB. See later slide.
- However, the balance of transmitter and receiver difficulty may differ between 200GBASE-FR4 and 400GBASE-FR8

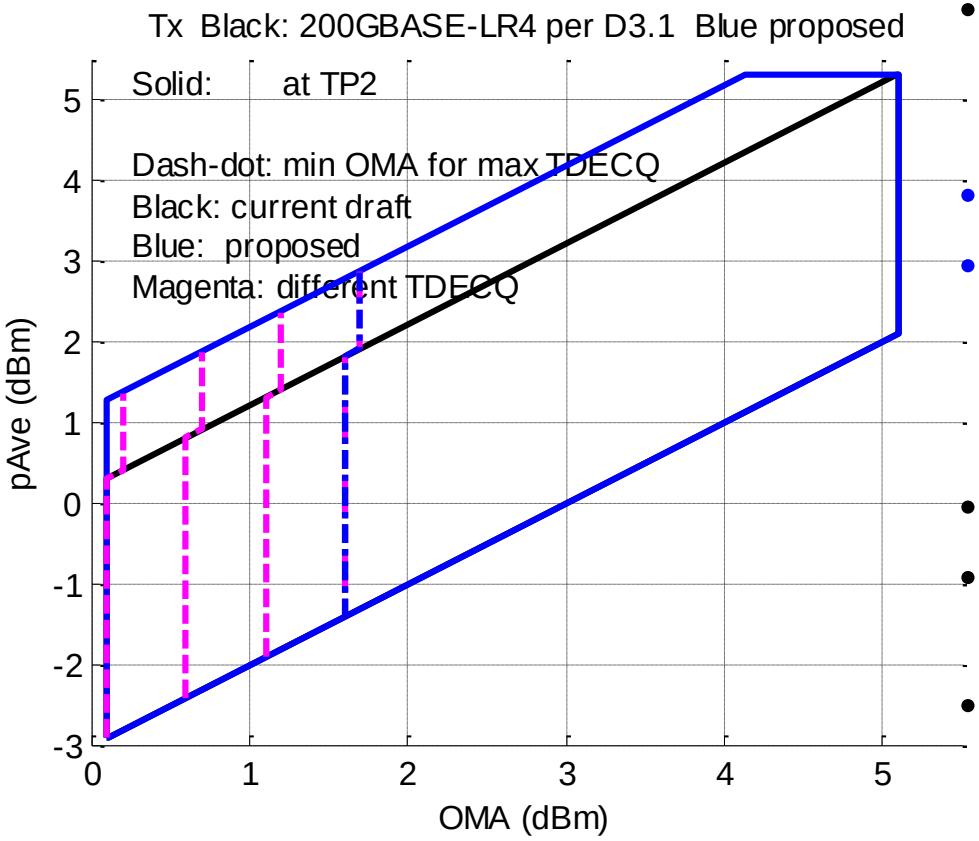
Transmitter setup map: 200GBASE-LR4



- Black polygon: Tx spec in D3.1, with 4.5 dB min. extinction ratio

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

200GBASE-LR4 setup map: proposal



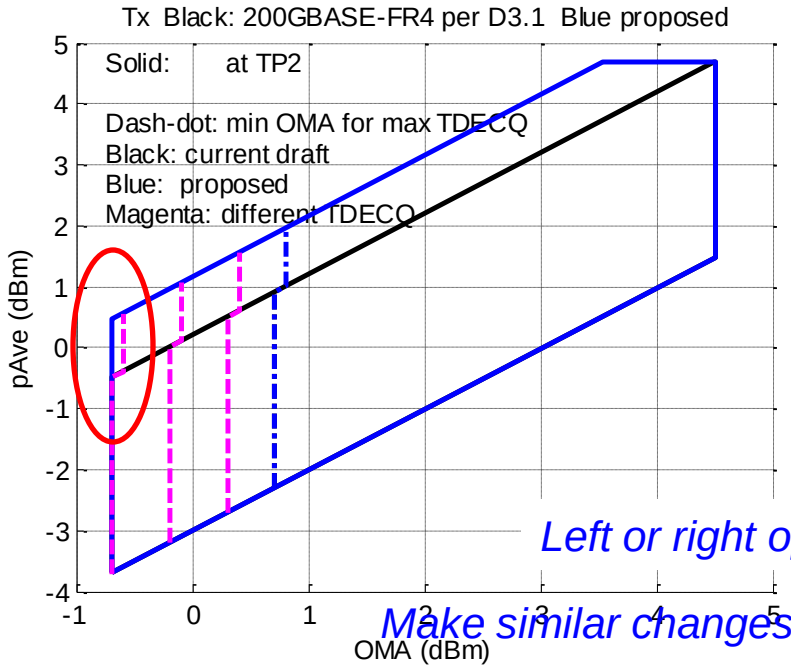
- A single Tx waveform measurement is used to find TDECQ, OMA, mean power, and extinction ratio

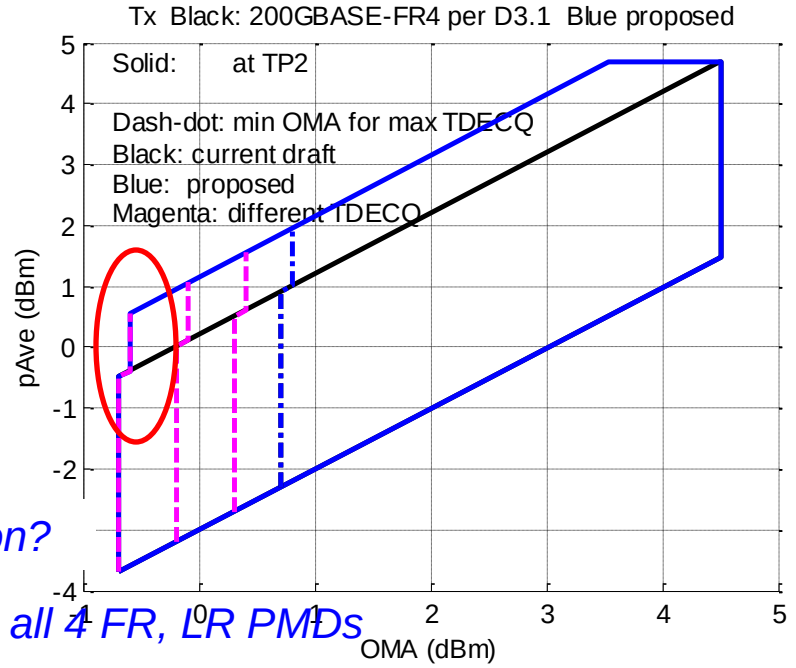
- Black polygon (partly hidden under blue one): Tx spec in D3.1, with 4.5 dB min. extinction ratio
- Blue polygon: proposal: 3.5 dB
- And 0.1 dB more OMA-TDECQ below 4.5 dB
  - For extra multipath interference penalty
  - anslow_01_0517_smf slides 3-6
- Tx spec becomes easier
- Channel, connectors and 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

200GBASE-LR4 and 400GBASE-LR8

- The extinction ratio and MPI considerations are the same for 200GBASE-LR4 and 400GBASE-LR8: same extinction ratio limit and discrete reflectance (Table 122–19)
  - This table might be re-optimised, about the pivot of **6** connectors at -35 dB. See later slide.
- However, the balance of transmitter and receiver difficulty may differ between 200GBASE-LR4 and 400GBASE-LR8

Consequential changes for 200GBASE-FR4, 200GBASE-LR4, 400GBASE-FR8, and 400GBASE-LR8





Left or right option?

Make similar changes for all 4 FR, LR PMDs

- Left: minimum OMA is the same for all extinction ratio
- Change Table 121–6, 200GBASE-DR4 transmit characteristics, note b, as below:
- Even if the TDECQ ~~< 1 dB~~ 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, the OMA_{outer} (min) must exceed this value.

- Right: stepped minimum OMA
- Change Table 121–6, 200GBASE-DR4 transmit characteristics, as below:
- Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min)[b]

Extinction ratio ≥ 5 dB	–0.7 dBm
3.5 dB < extinction ratio < 4.5 dB	–0.6 dBm

- [b]Even if the TDECQ < 1 dB, the OMA_{outer} (min) must exceed ~~this~~ these value.

Example change to transmitter table

Table 122–9—200GBASE-FR4 and 200GBASE-LR4 transmit characteristics

Description	200GBASE-FR4	200GBASE-LR4	Unit
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (min)[b]	~~0.7~~	~~0.1~~	~~dBm~~
Extinction ratio ≥ 4.5 dB	–0.7	0.1	dBm
3.5 dB < extinction ratio < 5 dB	–0.6	0.2	dBm
Launch power in OMA_{outer} minus TDECQ, each lane (min)	~~–1.7~~	~~–0.9~~	~~dBm~~
Extinction ratio ≥ 4.5 dB	–1.7	–0.9	dBm
3.5 dB < extinction ratio < 5 dB	–1.6	–0.8	dBm
Extinction ratio (min)	~~4.5~~ 3.5		dB

[b]Even if the TDECQ < 1 dB, the OMA_{outer} (min) must exceed ~~this value.~~ these values.

- This is the right option on the previous slide
- The left option is simpler
- For both DR4 PMDs, only the extinction ratio limit changes

Consequential changes to reflections in cable plant

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	
	200GBASE-FR4 or 400GBASE-FR8	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

Consequential change to budgets

- In Table 122–13, 200GBASE-FR4, 200GBASE-LR4, 400GBASE-FR8, and 400GBASE-LR8 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
- 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