# DR family interoperability, signal detect and average power limits

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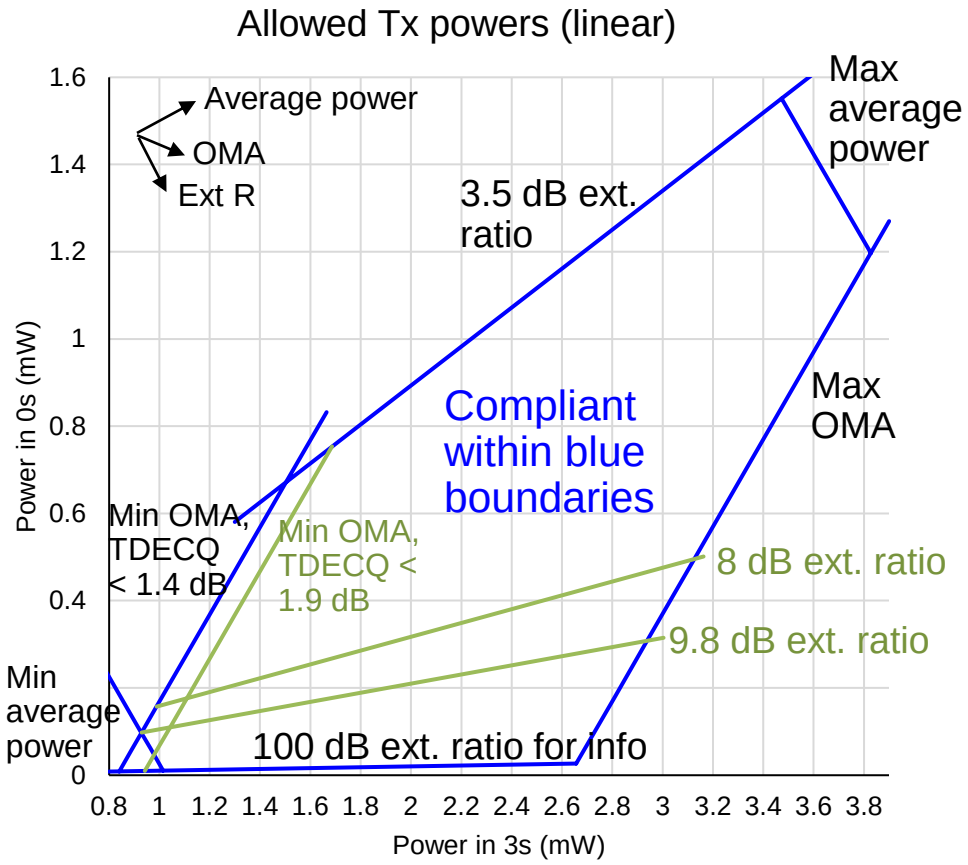
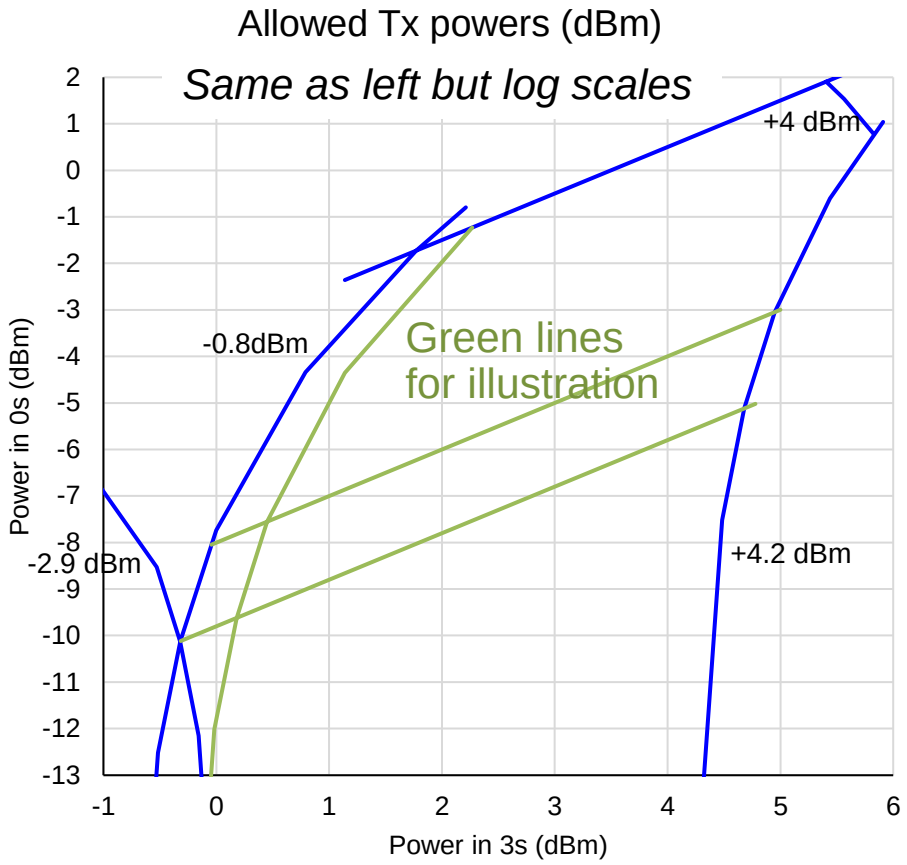
# Introduction

- For the DRn and DRn-2/FR1 family at 100G/lane and 200G/lane, there are several slightly different minimum average powers at the receivers
- This is inconvenient for multi-rate products and interoperability between these near-identical PHYs
- Signal detect limits should be revised so that interoperable signals are detected
- Unnecessarily wide average power ranges should be narrowed where they do not affect transmitter cost
- P802.3df D2.0 comments 84, 85, 86
  - Also note comment 12 which may affect the power levels for 400GBASE-DR4-2 and 800GBASE-DR8-2

# Transmit power map for 400GBASE-DR4

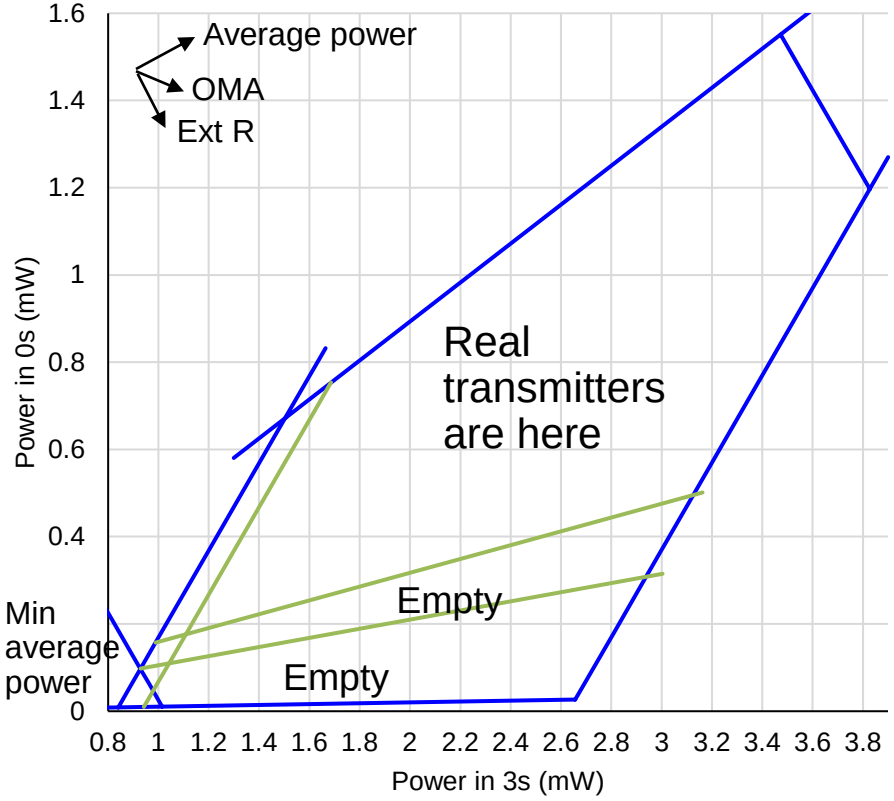


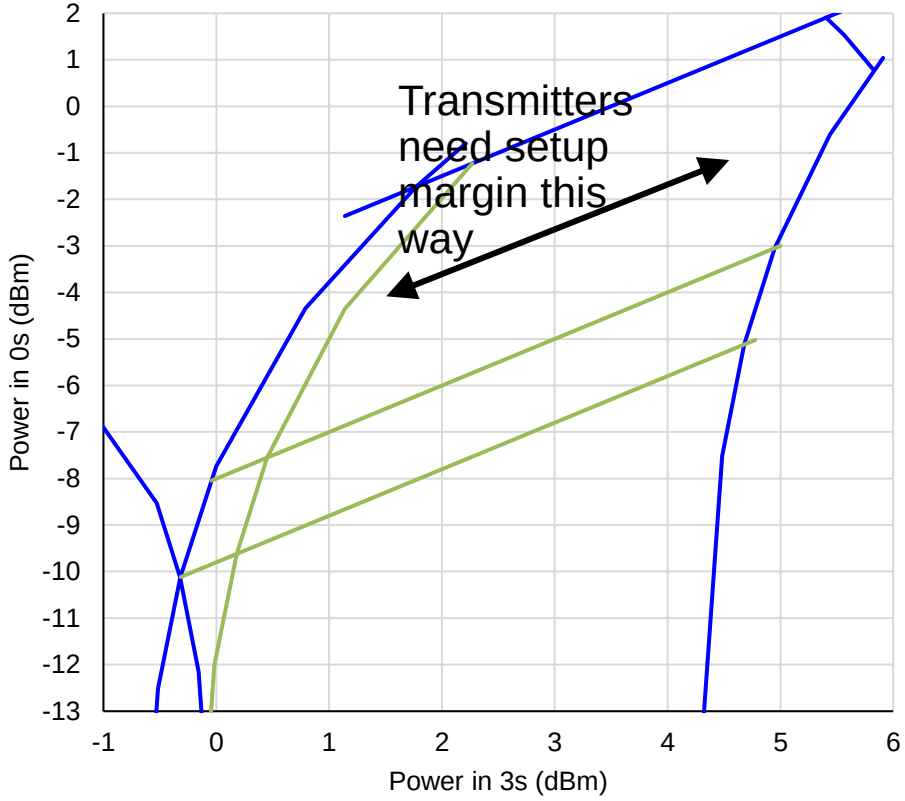

- DRn transmitter setup is defined by 5 limit lines:
- OMA min* and max, average power min and max, extinction ratio min (no max)
- * OMA min depends on TDECQ

# Transmit power map for 400GBASE-DR4

Allowed Tx powers (linear)




Allowed Tx powers (dBm)




- PAM4 links don't get a strong benefit from high extinction ratio
- Most PAM4 transmitter technologies struggle to deliver very high ext. R
- The minimum average power spec has no effect on real transmitters
- If transmitters were <8 dB ext. R, it could be moved up 0.5 dB

# Uses of average power and its limits

- Max limit is one of the ways of protecting the receiver from overload
- Min limit is for signal detect and interpreting the received power monitor
  - Min at Tx doesn't determine that the Tx signal is strong enough, in practice
    - Signal detect, set at or below min at Rx, is required to detect all compliant signals and some others, not to reject all non-compliant signals
  - The Rx average power is an input to network maintenance and diagnostics

# Accuracy of average power metric

- Channel loss is Tx average power – Rx average power
  - Tx average power min -2.9, max +4
  - 6.9 dB uncertainty – very poor
- Usable transmit power (in units of OMA) is OMA – TDECQ
- Usable power (in units of OMA) is OMA – ECQ
  - Average power and OMA are related by extinction ratio penalty, with a 3 dB offset from the 2-sided definition of OMA
  - Usable power (in units of OMA) is
    *Average power + 3 dB – extinction ratio penalty – TDECQ*

| Ext. R (dB) | Ext. R. penalty (dB) | TDECQ (dB) | | |
|---|---|---|---|---|
| Very high | 0 | Practical min | Min. credited | Max |
| 9.8 | 0.9 | ~0.7 | 1.4 | 3.4 |
| 8 | 1.4 | | | |
| 3.5 | 4.2 | | | |

  - 4.2 dB of uncertainty from hypothetical extinction ratio range, plus 2.7 dB from ECQ range. 6.9 dB uncertainty, also very poor

# Example use of average power

- If the average receive power is at the spec minimum of -5.9 dBm,
  - the usable power is between -5.9 +3 -4.2 -3.4 = -10.5 dBm and -5.9 +3 -0.7 = -3.6 dBm
  - the loss of the channel is between -2.9 +5.9 = 3 dB and +4 +5.9 = 9.9 dBm
- These ranges are far too wide to be useful so we use product information or make sensible estimates of transmitter TDECQ and extinction ratio to narrow them (or in a more expensive debug, go to the other end of the link and check out the transmitter)
- If the minimum average Tx power were raised from -2.9 dBm to -2.4 dB, the official uncertainty in channel loss would be reduced by 0.5 dB, any very lucky low-power transmitters with TDECQ <= 1.4 dB and extinction ratio > 8 dB would need to increase their output power by <= 0.5 dB
- If the minimum average Tx power were lowered from -2.9 dBm to -3.1 dB, the official uncertainty in channel loss would be increased by 0.2 dB, any very lucky low-power transmitters with TDECQ <= 1.4 dB and extinction ratio between 9.8 and 10.9 dB would be able to decrease their output power by <= 0.2 dB
  - But we believe that 100G/lane DRn-2 performance, with 0.7 dB higher minimum OMA, is readily achievable, so this is not necessary

# Comparing PMDs that could be connected together

| | PMD type | Min OMA | Min ave. power, Tx | Ext R at corner | Max loss | Min ave. power, Rx | Signal detect max | Remarks |
|---|---|---|---|---|---|---|---|---|
| 802.3 clause 121 | 200GBASE-DR4 | -3 | -5.1 | 9.8 | 3 | -8.1 | -8.1 | |
| 802.3 clauses 124 and 140, P802.3df D2.0 | 100GBASE-DR, 400GBASE-DR4, 800GBASE-DR8 | -0.8 | -2.9 | 9.8 | 2.6 to 3 | -5.9 | -5.9 | Low ave P min, could be raised, should not be lowered |
| | 100GBASE-FR1 | -0.1 | -3.1 | Infinite | 4 | -7.1 | -7.1 | Low ave P min should be raised |
| P802.3df D2.0 | 400GBASE-DR4-2 800GBASE-DR8-2 | -0.1 | -3.1 | Infinite | 4 | -7.1 | -7.1 | Low ave P min should be raised |
| welch_3dj_ 01b_2305 | 500 m Type 1 500 m Type 2 | +0.2 +0.1 | -2.8 -2.9 | Infinite Infinite | 3 | -5.8 -5.9 | | Ave P min should all be the same, SD max should all be the same |
| | 2 km Type 1 2 km Type 2 | +0.9 +0.8 | -2.1 -2.2 | Infinite Infinite | 4 | -6.1 -6.2 | | |
| 802.3 Clause 124 | 100GBASE-LR1 | +1.1 | -1.9 | Infinite | 6.3 | -8.2 | -8.2 | Ave P min could be raised by 0.9 dB |
| Remarks | | | | Not a max | | Should be harmonised | Should be the lowest of several min Rx | |

# Proposed coordinated improvements

| | PMD type | Min OMA | Min ave. power, Tx | Ext R at corner | Max loss | Min ave. power, Rx | Signal detect max | Remarks |
|---|---|---|---|---|---|---|---|---|
| 802.3 clause 121 | 200GBASE-DR4 | -3 | -5.1 | 9.8 | 3 | -8.1 | -8.1 | |
| 802.3 clauses 124 and 140, P802.3df D2.0 | 100GBASE-DR, 400GBASE-DR4, 800GBASE-DR8 | -0.8 | -2.9 | 9.8 | 2.6 to 3 | -5.9 | -5.9 -> -7.3 | Backward compatible |
| | 100GBASE-FR1 | -0.1 | -3.1 -> -2.2 | Inf -> 9.8 | 4 | -7.1 | -7.1 -> -7.3 | Backward compatible |
| P802.3df D2.0 | 400GBASE-DR4-2 800GBASE-DR8-2 | -0.1 | -3.1 -> -2.2 | Inf -> 9.8 | 4 | -7.1 | -7.1 -> -7.3 | Detects 100GBASE-DR and, in practice, 100-FR1 |
| welch_3dj_ 01b_2305 | 500 m Type 1<br>500 m Type 2 | +0.2<br>+0.1 | -2.8<br>-2.9<br>-> -2.2 | Inf -> 11.6<br>Inf -> 10.9 | 3 | -5.8<br>-5.9<br>-> -5.2 | -7.3 | Making 200G DRn, DRn-2, FR1 ave P min and SD max all the same |
| | 2 km Type 1<br>2 km Type 2 | +0.9<br>+0.8 | -2.1<br>-2.2 -> -2.1 | Inf<br>Inf -> 19.4 | 4 | -6.1<br>-6.2<br>-> -6.1 | | |
| 802.3 Clause 124 | 100GBASE-LR1 | +1.1 | -1.9 -> -1 | Inf -> 9.8 | 6.3 | -8.2 | -8.2 | Backward compatible. No strong reason to raise SD max |
| Remarks | | | Reduce slop | | | Align 100G/lane SD and lowest 100G/lane ave P min | | |

* but the weakest signal from compliant Tx and channel would be -7.3, which drives the SD limit for other PMDs

# Alternative weaker coordinated improvements

| | PMD type | Min OMA | Min ave. power, Tx | Ext R at corner | Max loss | Min ave. power, Rx | Signal detect max | Remarks |
|---|---|---|---|---|---|---|---|---|
| 802.3 clause 121 | 200GBASE-DR4 | -3 | -5.1 | 9.8 | 3 | -8.1 | -8.1 | |
| 802.3 clauses 124 and 140, P802.3df D2.0 | 100GBASE-DR, 400GBASE-DR4, 800GBASE-DR8 | -0.8 | -2.9 | 9.8 *Comment 84* | 2.6 to 3 | -5.9 | -5.9 -> -7.1 | Backward compatible |
| | 100GBASE-FR1 | -0.1 | -3.1 -> -2.9 | Inf -> 16.4 | 4 | -7.1 | -7.1 | Backward compatible |
| P802.3df D2.0 | 400GBASE-DR4-2 800GBASE-DR8-2 | -0.1 | -3.1 -> -2.9 | Inf -> 16.4 *Comments 85, 86* | 4 | -7.1 -> -6.9 | -7.1 | Detects 100GBASE-FR1 |
| welch_3dj_ 01b_2305 | 500 m Type 1<br>500 m Type 2 | +0.2<br>+0.1 | -2.8<br>-2.9 -> -2.8 | Inf<br>Inf | 3 | -5.8<br>-5.9<br>-> -5.8 | -7.1 | Making 200G DRn, DRn-2, FR1 ave P min and SD max consistent |
| | 2 km Type 1<br>2 km Type 2 | +0.9<br>+0.8 | -2.1<br>-2.2 -> -2.1 | Inf<br>Inf -> 19.4 | 4 | -6.1<br>-6.2<br>-> -6.1 | | |
| 802.3 Clause 124 | 100GBASE-LR1 | +1.1 | -1.9 | Inf | 6.3 | -8.2 | -8.2 | No change |
| Remarks | | | Reduce inconsistencies | | | Align 100G/lane SD and lowest 100G/lane ave P min | | |