# Specification methodology for 100GBASE-ZR & 400GBASE-ZR

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# Introduction

**This presentation is following up to the discussions in Salt Lake City on specification methodology for 100GBASE-ZR & 400GBASE-ZR.**

**Straw poll #1, “I support using a common optical specification methodology for 100 Gb/s and 400 Gb/s in P802.3ct”,**
**Result: Y: 25, N: 0, Need more information: 3.**

- **This indicated strong consensus that the same specification methodology should be used for both 100GBASE-ZR and 400GBASE-ZR.**

**Straw poll #2, “As the basis of the 100GBASE-ZR and 400GBASE-ZR optical spec baselines I support:**
**A) the tables and listed parameters on slides 5 –7 from stassar_3ct_01a_0519,**
**B) individual measurable Rx impairment compliance as per zhang_3ct_01a_0519”,**
**Result: A: 8, B: 9, Need more information: 10.**

- **This indicated lack of consensus on the fundamental approach for the specification methodology and a need to continue the discussion.**

**This presentation is trying to investigate the differences between the two proposals in order to identify an approach suitable for IEEE 802.3 specifications.**

# Proposed approaches

**The approach proposing individual measurable Rx impairment compliance per http://www.ieee802.org/3/ct/public/19_05/zhang_3ct_01a_0519.pdf, appears to largely follow the approach in OIF's 400ZR project, as described on slide 6 of zhang_3ct_01a_0519.**

**The approach for the tables and listed parameters on slides 5 –7 from http://www.ieee802.org/3/ct/public/19_05/stassar_3ct_01a_0519.pdf, is based upon the traditional specification approach in IEEE 802.3 (and also ITU-T) of a requirements document, providing high level system requirements and associated (optical) interface specifications, independent of specific implementations.**

**What is the difference between the approaches in OIF and those traditionally used in IEEE 802.3?**

# The approach for 400ZR in OIF

**As noted in the latest Liaison Statement from the OIF, its draft 400ZR document is specifically described as an Implementation Agreement (IA) for a Digital Coherent 400ZR interface for two applications: 120 km or less, amplified, point-to-point, DWDM noise limited links and unamplified, single wavelength, loss limited links.**

**Also, the IA aims to enable interoperable, cost-effective, 400Gb/s implementations based on single-carrier coherent DP-16QAM modulation, low power DSP supporting Absolute (Non-Differential) phase encoding/decoding, and a Concatenated FEC (C-FEC) with a post-FEC error floor <1.0E-15.**

**It's furthermore noted that no restriction on the physical form factor is implied by this IA, but the specifications target a pluggable DCO architecture with port densities equivalent to grey client optics.**

**The electrical (host) interface is specified as 400GAUI-8 C2M or 8 x CEI-56G-VSR PAM-4, thus on the basis of 8x 50 Gb/s PAM4 electrical.**

**This approach effectively makes the OIF document a module, and thus a functional, product specification.**

# The traditional approach in IEEE 802.3

**Traditionally IEEE 802.3 specifications provide a series of requirements documents, which can be used as a basis to design a variety of implementations.**

For instance the specification for 400GBASE-LR8 in Clause 122 of IEEE Std 802.3-2018 is not limited to a single electrical interface specification. Table 122-1, provides a list of optional C2M and C2C electrical interfaces, 400GAUI-16 (16x 25 Gb/s NRZ) and 400GAUI-8 (8x 50 Gb/s PAM4).

**So IEEE 802.3 does not create a functional module or product specification.**

**It creates end-to-end requirements by specifications at various interface points, including a link specification.**

# Overall performance requirement

**The overall system requirement for the example of 400GBASE-LR8 is defined in subclause 122.1.1, bit error ratio, in this example being:**

"*The bit error ratio (BER) when processed according to Clause 120 shall be less than 2.4 × $10^{–4}$ provided that the error statistics are sufficiently random that this results in a frame loss ratio of less than 1.7 × $10^{–12}$ for 64-octet frames with minimum interpacket gap when processed according to Clause 120 and then Clause 119*."

**This is the overall requirement that needs to be met by the PMD specification.**

# Dealing with penalty allocations in zhang_3ct_01a_0519

## Rx Optical Specs

| Description | Value | Unit |
|---|---|---|
| Input Power Range (min) | -12 | dBm |
| Input Power Range (max) | 0 | dBm |
| Frequency Offset Tolerance (min)[a] | ± 1.8 | GHz |
| OSNR Tolerance (min)[b] | 26 | dB |
| CD Tolerance (min) [c] | 1600 | ps/nm |
| DGD (max)[d] | 33 | ps |
| SOPMD (max)[d] | 272 | $ps^2$ |
| Peak PDL Tolerance (min)[e] | 3.5 | dB |
| Change in SOP Tolerance (min)[f] | 50 | rad/ms |
| Optical Power Transient Tolerance (min)[g] | ± 2 | dB |
| Optical return Loss (min) | 20 | dB |
| Optical filtering bandwidth tolerance (min)[h] | TBD | GHz |

a). Rx must tolerate this amount of Tx frequency offset from the nominal ITU center frequency grid.
b). Minimum value of OSNR (referred to 0.1 nm noise bandwidth @ 193.6 THz) that can be tolerated while maintaining the maximum BER below the CFEC threshold. Must be met for a back-to-back measurement configuration at all input powers defined above.
c). Tolerance to chromatic dispersion with <0.5 dB OSNR penalty
d). Tolerance to max DGD and max SOPMD [according to 10ps mean PMD] with < 0.5 dB OSNR penalty and change in SOP < 1 rad/ms.
e). Peak PDL includes both transmitter polarization imbalance and black link PDL. Tolerance to peak PDL with < 1.3 dB OSNR penalty. Tested with noise injected after PDL emulator and PSP < 1 rad/ms.
f). Tolerance to change in SOP with < 0.5 dB OSNR penalty.
g). Tolerance to change in input power with < 0.5 dB OSNR penalty.
h). Tolerance to link bandwidth narrowing effect together with TX spectral excursion with <0.5dB OSNR penalty; bandwidth in GHz defined with double side band in regards to the ITU grid.

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**Proposing to specify separate OSNR penalties at Rx input for various impairments:**

- **0.5 dB for 1600 ps/nm**
- **0.5 dB for 33 ps max DGD and 272 ps max SOPMD**
- **1.3 dB for 3.5 dB PDL**
- **0.5 dB for 50 rad/ms SOP**
- **0.5 dB for ±2 dB input power change**
- **0.5 dB for TBD optical filtering tolerance**

# IEEE 802.3 approach for dealing with penalty allocations

**IEEE 802.3 historically defines:**

- **A single penalty metric for the transmitter, TDP for NRZ and TDECQ for PAM4.**
  - **Combination of basic pulse "degradation" and chromatic dispersion penalty.**

- **A bulk "allocation for penalties (at maximum TDP or TDECQ)" for the link:**
  - **Depending on the specific application several penalties are included without being separately specified.**
  - **E.g. for 400GBASE-LR8, total allocation for penalties 3.8 dB (ER ≥ 4.5 dB). During spec creation phase extensive analysis was carried out to include maximum MPI penalty of 0.5 dB**
  - **For 40 km applications an additional allocation for DGD penalty has been included, so allocations for MPI and DGD penalties are included without separate limits.**

- **This approach allows device vendors to trade off the various penalties, so that the total performance stays within limits to enable optimized manufacturing at lowest cost.**

# Potential issues with penalty approach in zhang_3ct_01a_0519.pdf

**In zhang_3ct_01a_0519.pdf, as shown on slide 7 of this presentation, it is proposed to separately specify penalties for various impairment limits one by one at the Rx input.**

**Impact of implementing separate penalties:**

- **If impairments are measured separately, then a certain device may fail the specification for one impairment while the penalties due to other impairments may be extremely low. This could be a device working perfectly OK in the application while it would fail the IEEE 802.3 specification. So one would reject a good device.**
- **A device may meet impairment penalties separately, and thus meet the intended specification, while the total penalty when impairments are combined could go off a cliff and thus one would ship a device that will fail in the application.**

**Questions on the approach in zhang_3ct_01a_0519.pdf:**

- **How to correlate the separate penalties under combined impairment situations**
- **How to relate the separate penalties to the total system requirements.**

# General specification approach

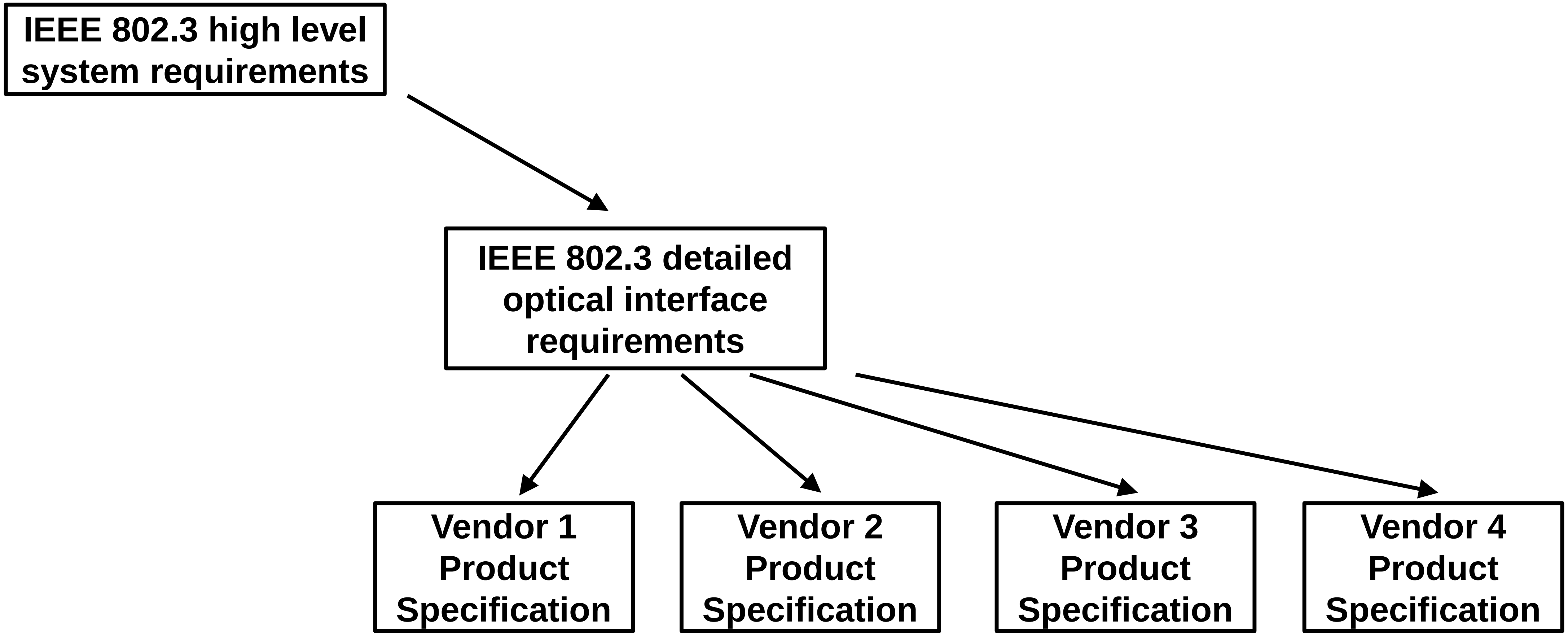
## The following basic objectives for the specification approach are assumed:

- **A device meeting the specification works in the application.**
- **A device failing the specification does not work in the application.**

## While trying to avoid:

- **A device meeting the specification, while not working properly in the application (unhappy customers and RMAs).**
- **A device not meeting the specification, thus being rejected in manufacturing, while it would have worked satisfactorily in the application (reduced yield and thus increasing cost).**

# General specification approach




**Translation from optical interface requirements into vendor specific product specifications likely is design and/or implementation dependent and therefore potentially different.**

# High level differences between 2 approaches

**The approach for specifying individual measurable Rx impairment compliance in zhang_3ct_01a_0519 is almost the same at in OIF's 400ZR draft specification, which is specifically an implementation agreement and therefore pretty close to a device/product specification, which may be different for different vendors. This approach seems specifically intended to create compliance conformance testing requirements.**

**The approach proposed in stassar_3ct_01a_0519 is in keeping with the historic/conventional IEEE 802.3 approach to create requirements documents, implementation independent, allowing performance trade-off, not including compliance conformance testing requirements.**

# NEXT

# DISCUSSION

Thanks!