

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

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Introduction

This presentation is following up to the discussions in Salt Lake City, May 2019, and on the interim teleconference on 6 June 2019 on specification methodology for 100GBASE-ZR & 400GBASE-ZR. Some updates are made to the 6 June presentation, [stassar 3ct 01 190606](#).

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

Straw polls in Salt Lake City, May 2019

**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.

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.

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 \geq 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

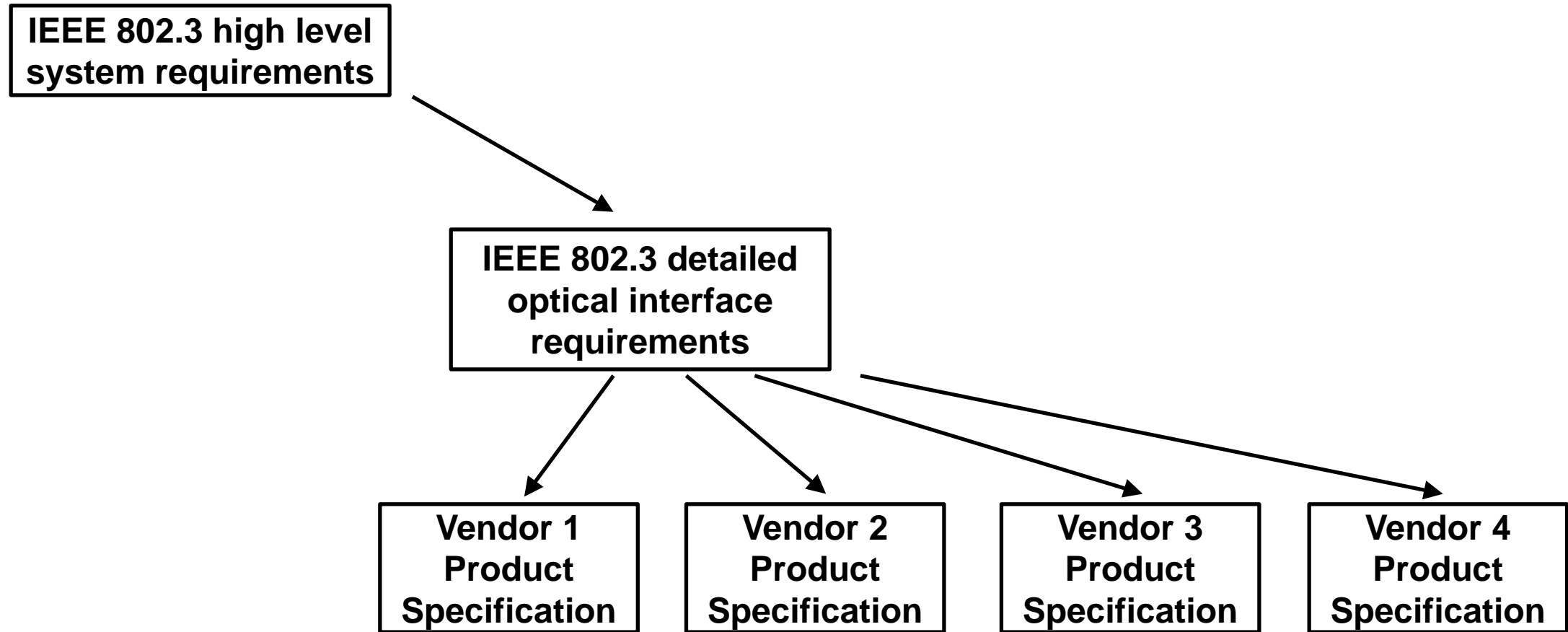
The following basic objectives for the specification approach are assumed:

- **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.

Proposal to include example values for individual Rx penalties

The “bridge proposal” in

http://www.ieee802.org/3/ct/public/tf_interim/19_0627/maj_3ct_01_190627.pdf,

to include an example table for allocation of individual Receiver impairment penalties,

has a high risk of being interpreted as normative requirements and will have a similar effect as making them normative.

Past experience has shown that including example parameter values in standards will be interpreted by some end users as hard requirements, which has a high risk of rejecting devices which do work in the application.

High level differences between 2 approaches

The approach for specifying individual measurable Rx impairment compliance in zhang_3ct_01a_0519 is almost the same as 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!