Optical Specifications for Different FEC Modes at 200G/L - Methodology

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Overview

- Several Ad-Hoc contributions have sought clarification on the means of defining optical specifications to support operation with and without inner code FEC.
  - dambrosia_3dj_optx_01b_230815.pdf
  - dambrosia_3dj_optx_01a_230829.pdf

- The intent of this presentation is to provide clarification where possible, and to propose definitions and methodologies to satisfy both FEC directions.

Clarification 1: Use of the term bypass

- The term “bypass” was used to indicate that the goal of the RS(544,514) only operating modes was used to supplement, but not replace, the goal of operating with an additional inner FEC.
- The proposal for this and future presentations is to instead use the following definitions:
  - **Mode_FECo**: Optical link runs with RS(544,514) FEC protection.
  - **Mode_FECi**: Optical link runs with RS(544,514) FEC protection operating as an outer code, supplemented by Hamming(128,120) FEC protection operating as an inner code.
- This should avoid confusion with prior 802.3 uses of the word “bypass”.

Clarification 2: Standardization of Different FEC Modes

- Optical specifications could be codified in 802.3 in two ways:
  - As a common PMD/PHY specification defining operation for both FEC modes
  - As separate PMD/PHY specifications for each FEC mode

- Both modes were presented/discussed in welch_3dj_04a_2307.pdf, however no recommendation was made at that time.
  - It is understood that the “separate PMD/PHY” approach would require new objectives, whereas the “common PMD/PHY” approach would not.

- Depending on the option pursued, specifications to support interoperability between the two modes may be required.
  - Example: Auto-Detection vs. Auto-Negotiation

Clarification 3: Market Acceptance

- **Question:** Will the market accept a single PHY dual mode approach?

- **Answer:** Yes. End users may place their own restrictions on optics purchases to ensure a specific mode of operation, however such behaviors are common today.
  - EX: It is typical for customers to ask for better than spec compliance on transmitter performance (OMA, TDECQ) or receiver performance (SRS, BER) than the standards require.
  - This is much more common than creating fundamentally new specs to support their needs

- **Note:** End users likely will not want to reduce reach to enable operation without an inner FEC
  - Even today users frequently use higher loss PMD/PHY types for shorter reaches, to maintain a common PMD/PHY type across their installation.
  - Reach is also a small contributor of loss budget in 500m and 2km SMF infrastructures

Clarification 4: Identification

- **Question:** How will users identify “lower latency” PHYs?
  - Assuming the standard does not differentiate.

- **Answer:** This can be achieved various ways, including:
  - Through having specific purchasing requirements, met with specific product datasheets ensuring “lower latency” compliance.
  - Through EEPROM advertising/status bits, as are commonly used today to indicate optical module performance.

- **Note:** Many things not explicit in IEEE PMD/PHY nomenclature but critical to market acceptance must be identified in optical modules:
  - EX: Form Factor, Power, Optical Connector, Memory Map
  - Other IEEE standards (100GBASE-ZR) also require additional identification beyond PMD/PHY name (ie, to accommodate different wavelengths).

Clarification 5: Optical Transmitters

- **Question:** Will all future optical transmitters meet TxA requirements (i.e. no inner FEC necessary)

- **Answer:** It is unknown if all future optical transmitters will meet the requirement, and if so when. Experience at 100G/L suggest that considerable technology improvement is possible over the first 2-3 years of production, although that does not guarantee such evolution at 200G/L.

Clarification 6: Low Latency PHY

- **Question:** Will an optimized low latency only PHY (no inner FEC) be desired?

- **Answer:** As was indicated in clarification 3, end users (especially in web-scale deployments) may implement their own restrictions against an 802.3 spec to guarantee low latency PHY performance where needed. Having a separate PHY type may make this easier (and more universal among consumers) but is not considered to be necessary.

Optical Spec Methodologies

Optical Spec Methodologies – Two Approaches

- **Common Optical Spec:** Common spec defining both KP4 FEC only operation and KP4+InnerFEC operation.

- **Separate Optical Specs:** Separate PMDs, one for KP4 only operation and another for KP4+InnerFec operation.

Common Optical Specification

Common spec/PMD defining both KP4 FEC only operation and KP4+InnerFEC operation

Common Optical Specification

- Transmitter is **allowed** to comply to **either** Mode_FECo or Mode_FECi operating condition

- Receiver is **required** to comply to **both** Mode_FECo and Mode_FECi operation conditions

Proposed Transmitter Specifications

Description	n00GBASE-nR4		Unit
	Mode_FECo	Mode_FECi	
Signaling rate, each lane (range)	106.25 ± 50 ppm	113.4375 ± 50 ppm	GBd
Modulation Format	PAM4		
Lane wavelengths (range)	*Value*		nm
Side-mode suppression ratio (SMSR), (min)	*Value*		dB
Average launch power, each lane (max)	*Value*		dBm
Average launch power, each lane (min)	*Value*		dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane(max)	*Value*		dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane(min) for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ TDECQ (max)	 *Value* *Value*		 dBm dBm
Transmitter and dispersion eye closure (TDECQ), each lane (max)	*Value*	*Value*	dB
TECQ (max)	*Value*	*Value*	dB
|TDECQ - TECQ| (max)	*Value*	*Value*	dB
Average launch power of OFF transmitter, each lane (max)	*Value*		dBm
Extinction ratio, each lane, (min)	*Value*		dB
Transmitter transition time (max)	*Value*		ps
Transmitter over/under-shoot (max)	*Value*		%
RIN_xOMA (max)	*Value*		dB/Hz
Optical return loss tolerance (max)	*Value*		dB
Transmitter reflectance (max)	*Value*		dB

Proposed Receiver Specifications

Description	n00GBASE-nR4		Unit
	Mode_FECo	Mode_FECi	
Signaling rate, each lane (range)	106.25 ± 50 ppm	113.4375 ± 50 ppm	GBd
Modulation Format	PAM4		
Lane wavelengths (range)	*Value*		nm
Damage threshold, each lane	*Value*		dBm
Average receive power, each lane (max)	*Value*		dBm
Average receive power, each lane (min)	*Value*		dBm
Receive power, each lane (OMA_{outer}) (max)	*Value*		dBm
Receiver reflectance (max)	*Value*		dB
Receiver sensitivity (OMA_{outer}), each lane (max) for TECQ < 1.4 dB for 1.4 dB ≤ TECQ ≤ SECQ	 *Value* *Value*		 dBm dBm
Stressed receiver sensitivity (OMA_{outer}), each lane (max)	*Value*	*Value*	dBm
Conditions of stressed receiver sensitivity test:			
SECQ	*Value*	*Value*	dB
OMA_{outer} of each aggressor lane[c]	*Value*		dBm

Proposed Link Budget

Description	n00GBASE-nR4		Unit
	Mode_FECo	Mode_FECi	
Power budget (for max TDECQ)	*Value*	*Value*	dB
Operating distance	*Value*		m
Channel insertion loss	*Value*		dB
Maximum discrete reflectance	*Value*		dB
Allocation for penalties (for max TDECQ)	*Value*	*Value*	dB
Additional insertion loss allowed	*Value*		dB

Separate Optical Specifications

Separate PMDs, one for KP4 only operation and another for KP4+InnerFec operation

Separate Optical Specifications

- Distinct PMD/PHY specifications for Mode_FECo and Mode_FECi
  - Each with unique transmitter, receiver, and link specifications

- No IEEE requirement for interoperability between the two
  - Ie, Mode_FECi receiver does not have to interoperate with Mode_FECo transmitters.
  - Informative interoperability specs may still be advantageous

- **Note**: This isn't a nomenclature presentation. As such "mode" designations are presently being used in the case of separate PMD/PHYs to avoid confusion.

Proposed Transmitter Specifications

Description	n00GBASE-nR4		Unit
	Mode_FECo	Mode_FECi	
Signaling rate, each lane (range)	106.25 ± 50 ppm	113.4375 ± 50 ppm	GBd
Modulation Format	PAM4	PAM4	
Lane wavelengths (range)	*Value*	*Value*	nm
Side-mode suppression ratio (SMSR), (min)	*Value*	*Value*	dB
Average launch power, each lane (max)	*Value*	*Value*	dBm
Average launch power, each lane (min)	*Value*	*Value*	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane(max)	*Value*	*Value*	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane(min) for TDECQ < 1.4 dB for 1.4 dB ≤ TDECQ ≤ TDECQ (max)	 *Value* *Value*	 *Value* *Value*	 dBm dBm
Transmitter and dispersion eye closure (TDECQ), each lane (max)	*Value*	*Value*	dB
TECQ (max)	*Value*	*Value*	dB
|TDECQ - TECQ| (max)	*Value*	*Value*	dB
Average launch power of OFF transmitter, each lane (max)	*Value*	*Value*	dBm
Extinction ratio, each lane, (min)	*Value*	*Value*	dB
Transmitter transition time (max)	*Value*	*Value*	ps
Transmitter over/under-shoot (max)	*Value*	*Value*	%
RIN_xOMA (max)	*Value*	*Value*	dB/Hz
Optical return loss tolerance (max)	*Value*	*Value*	dB
Transmitter reflectance (max)	*Value*	*Value*	dB

Proposed Receiver Specifications

Description	n00GBASE-nR4		Unit
	Mode_FECo	Mode_FECi	
Signaling rate, each lane (range)	106.25 ± 50 ppm	113.4375 ± 50 ppm	GBd
Modulation Format	PAM4	PAM4	
Lane wavelengths (range)	*Value*	*Value*	nm
Damage threshold, each lane	*Value*	*Value*	dBm
Average receive power, each lane (max)	*Value*	*Value*	dBm
Average receive power, each lane (min)	*Value*	*Value*	dBm
Receive power, each lane (OMA_{outer}) (max)	*Value*	*Value*	dBm
Receiver reflectance (max)	*Value*	*Value*	dB
Receiver sensitivity (OMA_{outer}), each lane (max) for TECQ < 1.4 dB for 1.4 dB ≤ TECQ ≤ SECQ	 *Value* *Value*	 *Value* *Value*	 dBm dBm
Stressed receiver sensitivity (OMA_{outer}), each lane (max)	*Value*	*Value*	dBm
Conditions of stressed receiver sensitivity test:			
SECQ	*Value*	*Value*	dB
OMA_{outer} of each aggressor lane[c]	*Value*	*Value*	dBm

Proposed Link Budget

Description	n00GBASE-nR4		Unit
	Mode_FECo	Mode_FECi	
Power budget (for max TDECQ)	*Value*	*Value*	dB
Operating distance	*Value*	*Value*	m
Channel insertion loss	*Value*	*Value*	dB
Maximum discrete reflectance	*Value*	*Value*	dB
Allocation for penalties (for max TDECQ)	*Value*	*Value*	dB
Additional insertion loss allowed	*Value*	*Value*	dB

Summary

- Two options available for supporting different FEC modes:
  - Common Optical Specification: Single PMD/PHY
  - Separate Optical Specifications: Separate PMD/PHYs

- Either option acceptable to the market:
  - End users with FEC/Latency sensitivity may create restricted specs based on their specific needs.

- Biggest difference likely to be the need for adaptation spec for common PMD/PHY approach vs. the need for additional objectives for separate PMD/PHY approach