Path to a baseline proposal for copper and backplane PMD clauses

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October 2014

Introduction

- This presentation aims at laying out the required components of a cable/backplane PMDs baseline proposal:
  - Suggested editorial structure
  - Technical components that require some work
  - Choices that do not seem obvious
- The three objectives accepted by the study group in the September interim serve as the foundation:

- Define a single-lane 25 Gb/s PHY for operation over a printed circuit board backplane consistent with channels specified in IEEE Std 802.3bj-2014 Clause 93
- Define a single-lane 25 Gb/s PHY for operation over links consistent with copper twin axial cables, with lengths up to at least 3m
- Define a single-lane 25 Gb/s PHY for operation over links consistent with copper twin axial cables, with lengths up to at least 5m

General ideas

- Assume a new clause will be created for a single-lane copper cable PMD
  - Refer back to clause 92 wherever appropriate
- Assume a new clause will be created for a single-lane backplane PMD
  - Refer back to clause 93 wherever appropriate
- Share structure and content between the backplane and cable PMD clauses where possible
- Possible new concepts for the cable PMD:
  - More than one PMD “class” (exact definition has to be decided), so multiple electrical specifications
  - More than one loss budget, so multiple channel constructions
  - Choice of using FEC, possibly two FEC types, possibly different PCS encodings
  - Choice of MDIs

Note: “class” used here temporarily until we decide on nomenclature (type, subtype, optional feature, or combinations)

General structure – copper cable clause

Subclauses of clause 92 (**Boldface text** means a possibly non-obvious change; ~~strikethrough text~~ means subclause can be omitted)

1. Overview
2. PMD service interface
3. **PCS requirements for AN**
4. Delay constraints
5. ~~Skew constraints~~
6. PMD MDIO function mapping
7. **PMD functional specifications**
8. **PMD electrical characteristics**
9. ~~Channel characteristics~~
10. **Cable assembly characteristics**
11. **Test fixtures**
12. **MDI specifications**
13. Environmental specifications
14. PICS

Details of possible non-trivial changes

- **PCS requirements for AN**
  - AN determines PHY choice and FEC encoding (which may in turn affect PCS behavior)
  - If the PHY includes an AUI, in order to communicate AN PHY choice towards the FEC and PCS, some management registers may be required (this is actually a requirement for AN)
- **PMD functional specifications**
  - A possible way to determine use of FEC is using PMD training
  - If we choose this, operation over a 25G-AUI-C2C would also require a way to communicate this towards the FEC and PCS (variables, management registers)
- **PMD electrical characteristics**
  - Several sets of specifications
- **Channel characteristics + Cable assembly characteristics**
  - In 802.3bj, channel characteristics subclause (92.9) has only one paragraph; it could be merged with cable assembly characteristics (92.10) to a single subclause
  - Different PMD combinations create several cable types, each has its own set of parameters
- **Test fixtures**
  - Could be moved to an annex, and shared with 25G AUI
- **MDI specifications**
  - New single-lane MDI
  - Possibly support 4-lane MDIs from clause 92 as well
  - We may also choose to address breakout cables

General structure – backplane clause

Subclauses of clause 93 (**Boldface text** means a likely non-obvious change; ~~strikethrough text~~ means subclause can be omitted)

1. Overview
2. PMD service interface
3. **PCS requirements for AN**
4. Delay constraints
5. ~~Skew constraints~~
6. PMD MDIO function mapping
7. **PMD functional specifications**
8. PMD electrical characteristics
9. Channel characteristics
10. Environmental specifications
11. PICS

Copper cable clause work can be re-used; no additional items

More details on loss budgets for cable

- **Two loss budget divisions were discussed at length in the SG:**
  1. 5 meter cable reach: keeping mandatory RS-FEC, PMD electrical specifications and COM parameters based on clause 92
  2. 3 meter cable reach
     a. Keeping PMD electrical specifications similar to clause 92, and using the lower loss to allow operation without FEC (or with clause 74 FEC)
     b. Keeping RS-FEC, and using the lower loss for relief of PMD electrical specifications, allowing higher loss on host PCB
- **Also mentioned: reduced host PCB loss for asymmetric allocation**
- **We may have n=2 or n=3 PMD classes, each with its own specifications**
  - This would create $\frac{n(n+1)}{2}$ combinations of two PMDs (➔ cable specs and tests)
  - Two PMDs ➔ three possible combinations
  - Three PMDs ➔ six possible combinations
  - May also imply multiple 25G-AUI-C2M specs
- **Consider methods to enable interoperability between PMDs of different classes**
  - Spans multiple clauses: PMD, AN, PCS, RS-FEC (and possibly base-R FEC), MDIO, management

TX specs for different PMD classes

- All PMD and cable classes use the same test point definitions
- Transmitter characteristics at TP2 will be different per PMD class
  - Can be summarized in a table like 92-6, but with multiple columns
  - Return losses, specified as frequency masks in 92.8.3.2 – 92.8.3.4, may vary
  - Transmitter output waveform linear fit procedure (92.8.3.5.1) may use separate values of N_p per class; specified limits will likely vary
  - Recommended TP0-TP2 and TP3-TP5 (92.8.3.6) will be different per class.
    - Consider moving these to an annex (note that recommended TP0-TP1 and TP4-TP5 already appear in an annex, which the 25G-AUI-C2M can re-use)
  - SNDR parameters and/or specified limit (92.8.3.7) may vary

Table 92–6—Transmitter characteristics at TP2 summary

Parameter	Subclause reference	Value	Units
Differential peak-to-peak output voltage (max.) with Tx disabled	92.8.3.1	35	mV
DC common-mode voltage (max.)	92.8.3.1	1.9	V
AC common-mode output voltage, v_{cmi} (max., RMS)	92.8.3.1	30	mV
Differential peak-to-peak voltage, v_{di} (max.)	92.8.3.1	1200	mV
Differential output return loss (min.)	92.8.3.2	See Equation (92–1)	dB
Common-mode to differential mode output return loss (min.)	92.8.3.3	See Equation (92–2)	dB
Common-mode to common-mode output return loss (min.)	92.8.3.4	See Equation (92–3)	dB
Transmitter steady-state voltage, v_f (min.) Transmitter steady-state voltage, v_f (max.)	92.8.3.5.2	0.34 0.6	V
Linear fit pulse peak (min.)	92.8.3.5.2	0.45 × v_f	V
Transmitted waveform abs coefficient step size (min.) abs coefficient step size (max.) minimum precursor full-scale ratio minimum post cursor full-scale ratio	 92.8.3.5.4 92.8.3.5.4 92.8.3.5.5 92.8.3.5.5	 0.0083 0.05 1.54 4	
Signal-to-noise-and-distortion ratio (min.)	92.8.3.7	26	dB
Output jitter (max.) Even-odd jitter, peak-to-peak Effective bounded uncorrelated jitter, peak-to-peak Effective total uncorrelated jitter, peak-to-peak	 92.8.3.8.1 92.8.3.8.2 92.8.3.8.2	 0.035 0.1 0.18	 UI UI UI
Signaling rate, per lane	92.8.3.9	25.78125±100 ppm	GBd
Unit interval nominal	92.8.3.9	38.787879	ps

RX specs for different PMD classes

- Receiver characteristics that may be different per PMD class:
  - Return losses (92.8.4.2 – 92.8.4.3)
  - Interference tolerance test channel parameters (92.8.4.4):
    - For a PMD with clause 92 loss budget:
      - Test with/without RS-FEC
      - For each of the above, test with the shortest and the longest cable
      - Total 4 test cases
    - For a PMD with higher loss budget:
      - Test only with RS-FEC, test with the shortest and the longest cable
      - Total 2 test cases

Cable specs

- Each cable type should meet specs matched with all PMD combinations that it supports
- Maximum insertion loss (92.10.2) will likely be different per class, return and conversion loss masks (92.10.3 – 92.10.6) may also vary
- Signal paths used for calculating COM (92.10.7.1.1) will be different
- See also diminico_25GE_01_1114

Choices we have to make

1. PMD classes for the copper cable PHY
   - How many?
   - Nomenclature – class, port, option? Separate PHYs? Some other term?

   Note, detailed parameters of the PMD classes may be left as TBD for now
2. Cable classes that can be used with each combination of PMD classes
   - All possible combinations, or limit to a subset (e.g. 3m and 5m only)?
   - Should we add nomenclature for these things?

   Note, detailed parameters of the cable classes may be left as TBD for now
3. Which MDIs? Breakout cables?
4. FEC choice, interoperability, negotiation
   - Are “with FEC” and “without FEC” considered as separate PHYs? or is it the same PHY, with one mandatory mode and one optional mode?
   - This will affect the cable PMD clause, even if most of the text resides in other clauses

Next steps

- Straw polls (during the November plenary or using SurveyMonkey afterwards) to sense which choices can build consensus
- Assuming we turn into a task force following the plenary meeting:
  - Work on a consensus baseline proposal based on the results (ad hoc work)
  - Ideally, adopt a baseline at the January interim

BACKUP

Combinations of 25GBASE-CR classes and implied cable reaches

Different combinations of two devices can result in different reaches being supported. The table may serve as an example.

Note: the titles and numbers in this table are for illustration only. They are practically TBD.

Host B \ Host A	"Higher loss"	Clause 92 spec	"Lower loss"
"Higher loss"	RS-FEC: 3 m	RS-FEC: ≥3 m	RS-FEC: 5 m? no FEC: 3 m?
Clause 92 spec	RS-FEC: ≥3 m	RS-FEC: 5 m no FEC: 3 m	RS-FEC: ≥5 m no FEC: ≥3 m
"Lower loss"	RS-FEC: 5 m? no FEC: 3 m?	RS-FEC: ≥5 m no FEC: ≥3 m	no FEC: ≥5 m

Highlighted cells could possibly support longer reaches, but could also be merged with higher-loss combinations, in order to limit the number of cable specifications.