Steps towards a fair PMD selection

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Introduction and objectives

- There have been several contributions in 803.3cz TF considering different PMDs: different fibers, different light wavelengths, different technologies
- Some of these PMD proposals have been developed in detail attending to multiple technical and economical aspects. Other PMD proposals have been just partially developed, e.g. no link budget, no reliability, etc. without demonstrating feasibility to meet the project objectives
- In the best situation, the 802.3cz TF should decide for a single PMD able to meet the 100% of project objectives and to maximize interoperability, multi-source and reduced cost
- If several PMDs are going to be included in the standard, the PMD plurality should be supported by very well justified market needs (final customer, i.e. OEM) and should support a very high level of interoperability
  - E.g. 802.3bv defined three PMDs, RHA, RHB and RHC.
    - The three PMDs shared almost 100% of TX and RX characteristics and were defined as necessity to meet project objectives attending to particularities unique of each target market: home networking, industrial automation and automotive
    - Differences: min AOP_{TP2}, AOP_{TP3} sensitivity, fiber length supported
    - The medium and the wavelength were the same

Introduction and objectives

- Every PMD proposal under consideration should be screened with common criteria
- These criteria will define a minimum threshold of quality that any PMD proposal that wants to be included in the 802.3cz should fulfill
- Based on these criteria, gaps as well as actions to fill them will be analyzed for each PMD proposal under consideration
- The TF should agree on the actions and their deadlines
- PMD proposals without filling the gaps should not be considered by the 802.3cz task force

Proposals under consideration — Proposal 1

- **VCSEL + OM3**
- **Objectives: 100% fulfilled**
  - 2.5, 5, 10, 25 Gbps over 40 m + 4 inline connections
  - 50 Gbps over 15 m + 2 inline connections
  - Feasibility: [1], [2], [17], [18]
  - Link budget: [3], [4], [5], [6]
- **Industry support (multi-source, automotive volume): the biggest**
  - OM3: many suppliers, good knowledge, decades of experience of deployment
  - InGaAs VCSEL: even bigger than 850 nm if we move to 980nm
  - In/GaAs PIN PD: big
  - PHY technology: standard CMOS, the biggest volume technology
- **Technical characteristics: mature knowledge**
  - OM3: well established parameters and test methods, validated independently by many laboratories. See [7]
  - VCSELs: identified concern of performance in extreme temperatures, but well supported in 802.3cz TF. See [8], [9], [10], [11], [12], [13]
- **Reliability: long experience and deep analysis of identified concerns**
  - OM3 is already used in harsh environments with extreme temperatures and mechanical requirements, e.g. avionics, militar, industrial automation, etc.
  - CMOS: automotive quality management services in place in the biggest foundries
  - In/GaAs PIN PD: very low current densities, long experience, no concerns
  - InGaAs VCSELs: identified concern of reliability, but well supported in the TF. See [14], [15], [16]
  - TRUMPF is running extensive reliability testing of 850nm and 980nm VCSELs. TRUMPF will report in summer, and the TF should decide wavelength based on results
- **Relative cost: well known, technology leveraging**
  - CMOS, In/GaAs PIN PD, inGaAs VCSELs, and fiber are leveraged from datacenter and other markets

Proposals under consideration — Proposal 2

- **VCSEL + GI-POF**
- **Objectives: limited**
  - 2.5, 5, 10 over 40 m + 4 inline connections
  - 25 Gbps over 15 m + 2
  - Feasibility: no real transmission at extreme temperatures have been demonstrated
  - Link budget: [19] (GI-POF parameters provided by AGC, not measured independently)
- **Industry support (multi-source, automotive volume): small**
  - GI-POF: only 2 suppliers AGC and Nitto
  - InGaAs VCSEL: same of proposal 1
  - In/GaAs PD: same of proposal 1
  - PHY technology: same of proposal 1
- **Technical characteristics: limited knowledge**
  - GI-POF: only reported by 1 vendor, AGC (see [20]); samples are not available for independent measurements
  - VCSELs: same of proposal 1
- **Reliability: limited knowledge**
  - GI-POF: limited data (see [20]). No reported use in harsh environment applications. Samples are not available or independent measurements
  - CMOS: same of proposal 1
  - In/GaAs PIN PD: same of proposal 1
  - InGaAs VCSELs: same of proposal 1
- **Relative cost: unknown for GI-POF**
  - CMOS, In/GaAs PIN PD, InGaAs VCSELs are well known
  - GI-POF relative cost is unknown compared with OM3

Proposals under consideration — Proposal 3

- **FP QD laser + Si Photonics + OM3, 1310 nm**
- **Objectives: unknown**
  - Partial information:
    - One TX eye-diagram of 25 Gb/s at Ta = 105°C (see [21] , [22] and [23]).
    - AOP and ER only reported at range 0 ~ 70 °C (see [23])
    - RX characteristics fo 25 Gb/s reported w/ CDR and FEC at range 0 ~ 70°C, see [23]. Not reported fiber length.
    - TX and RX characteristics at 32 Gb/s, 20°C, see [23]. Not reported fiber length.
    - No reported data at -40°C.
  - Link budget: unknown, no contributions
- **Industry support (multi-source, automotive volume): unknown**
  - Fiber:
    - If standard OM3 is used (per DMD specification), the application will receive the biggest support.
    - If OM2 (per OFL specification) is required, the support will be smaller.
    - If 1310nm optimized OM3 is required the support will be small.
  - TX: FP QD edge-emitting laser. Industry support from other data-com applications. Unknown volume.
  - RX: Ge on Silicon substrate. Unknown support.
  - PHY technology: Si photonics for MZ-modulators, wave-guides, grating couplers, optical pins. Unknown support.
- **Technical characteristics: limited knowledge**
  - Only partial information.
  - Unknown detailed characteristics of every part of the system in full range of temperature
  - Link budget is unknown
- **Reliability: limited knowledge**
  - OM2 and OM3 are already used in harsh environments with extreme temperatures and mechanical requirements, e.g. avionics, militar, industrial automation, etc.
  - Reported reliability only focused on one element: FP QD laser
  - Big concern on reliability of Si Photonics elements (MZ mods, couplers, pins)
  - Ge on Si substrate PD: unknown
  - Si Photonics: are the foundries qualified for automotive?
- **Relative cost: big concerns**
  - It is well known that Si Photonics is expensive in single lane applications compared with VCSEL based solutions (reason behind many 802.3 projects)
  - Only laser is ~5x VCSEL and it is not the most expensive part
  - A relative cost comparison should be addressed

Actions to fill the gaps

- Proposal 1 (VCSEL + OM3)
  - **Action 1**: Extensive reliability testing of 850 nm and 980 nm VCSELs. Ongoing. Results to be reported in summer. Then, TF should decide wavelength based on facts.
- Proposal 2 (VCSEL + GI-POF)
  - **Action 1**: Extensive reliability testing of 850 nm and 980 nm VCSELs. Shared with proposal 1
  - **Action 2**: AGC and Nitto to provide samples for round-robin testing by independent laboratories: CD, DMD and attenuation at 850 and 980 nm and environmental tests. Samples should be from different production lots.
  - **Action 3**: Based on obtained characterization results, repeat link budget analysis
  - **Action 4**: Contribution from a final customer, i.e. OEM, supporting the use of GI-POF, because objectives are only partially fulfilled
- Proposal 3 (Si Photonics)
  - **Action 1**: Characterization data of OM3 at 1310 nm (agreed by several OM3 suppliers): CD, DMD EMB, attenuation
  - **Action 2**: Contributions with characteristics of TX and RX in extreme temperatures (T_A between -40 and 105ºC)
  - **Action 3**: Link budget assessment for defined objectives
  - **Action 4**: Contributions on reliability analysis of Si Photonics elements and availability of automotive qualified fabs
  - **Action 5**: Contributions showing that Si Photonics transceivers can be produced in automotive volumes
  - **Action 6**: Relative cost comparison of single lane solution xMII to xMII (considering all the elements)
  - **Action 7**: Contribution from a final customer, i.e. OEM, supporting the use of Si Photonics, because interoperability does not exist with proposals 1 and 2

TODO list

- Add the actions intended to fill the gaps in the TODO list
- Define deadlines (short term) in the TODO list
- Avoid blocking the project

References

- [1] perezaranda_OMEGA_02c_1119_InGaAs_25G_VCSEL
- [2] perezaranda_OMEGA_01a_0120_50G_PAM4
- [3] perezaranda_3cz_01_271020_25G_link_budget
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- [6] perezaranda_3cz_02a_221220_reliability_linkbdget
- [7] pimpinella_3cz_01_271020
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- [10] perezaranda_OMEGA_03a_0720_VendorB_VCSEL
- [11] perezaranda_OMEGA_04a_0720_VendorC_VCSEL
- [12] perezaranda_OMEGA_05a_0720_VendorD_VCSEL
- [13] perezaranda_3cz_01b_0820_VendorE_VCSEL
- [14] perezaranda_OMEGA_05a_1119_VCSEL_Reliability
- [15] king_3cz_01_1120
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- [17] perezaranda_OMEGA_03_0120_25G_OFS_fiber
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- [19] perezaranda_3cz_01_090221_gipof_linkbudget
- [20] watanabe_3cz_01_090221_gipof
- [21] ogura_OMEGA_01_1119
- [22] ogura_OMEGA_01_0120
- [23] ogura_3cz_01_0121

Thank you!