Current situation on wavelength selection

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Introduction

- Remember this an **Automotive** project. 802.3cz project title: Physical Layer Specifications and Management Parameters for Multi-Gigabit Optical **Automotive** Ethernet.
- In [1] a holistic analysis about wavelength selection was presented attending to many aspects that affect the **automotive** application: VCSEL reliability, PHY complexity, OM3 fiber, photodiode material and flip-chip assembly
- It was concluded that 980nm is the best option for 802.3cz project (**automotive**)

	Wavelength (nm)		
Criteria	**850**	**940**	**980**
VCSEL wear-out reliability	Limited, current density needs to be under control in high temperature	Very good	Very good
VCSEL random failures reliability	No difference. Very good with low defect substrates		
VCSEL multi-vendor availability	Most of VCSEL suppliers fail	Reliable & high speed VCSELs are much easier to produce	
PHY complexity, TX FFE	Needed to compensate lower VCSEL bandwidth and AOP	Not needed	Not needed
PHY complexity, RX ADC + EQ	Higher complexity to compensate lower VCSEL bandwidth and AOP	Less complex	Less complex
OM3 fiber	No relevant difference. RX sensitivity loss due to reduced EMB is less than 0.3 dB at 40 meters at 50 Gb/s.		
Photodiode material	GaAs	InGaAs	InGaAs
Photodiode responsivity (A/W)	No relevant differences, ~ 0.6 A/W		
Flip-chip assembly option, TX	Not feasible. Big absorption.	Feasible, but process dependent	Feasible
Flip-chip assembly option, RX		Not feasible. Big responsivity penalty	Feasible

Reactions to wide band PMD proposal of [2]

- Just one reference to a paper has been provided in [2]. However, no details about the supposed used PIN photodiode are reported. Responsivity is contradictory with data reported for InGaAs photodiodes by many authors and providers in the industry (see [1])
- There is no doubt about the existence of SWDM PDs
- **However, are they suitable for 802.3cz (automotive)?**
- SWDM PD wide spectral response is not just a matter of AR coating. It is also a matter of photons absorption, InGaAs doping, band-gap engineering, vertical structures, etc.
- What is the **availability** of such kind of photodetectors developed for SWDM and which kind of technology is used to overcome the limitations of conventional GaAs and InGaAs photodiodes
  - How many **providers** are in the market with this kind of PD technology? — **Name** of the wide band PD providers is requested to be given to the TF
- **Maturity level**: this technology is very recent compared with InGaAs PDs. What is the experience of the industry about aging and PVT variations?
  - Is this PD technology suitable for automotive application? — Internal structure, compressive strains, lattice mismatches, failure modes, operation temperature range, reliability testing, qualification
- What is the **relative cost** of SWDM PD with respect to widely available and mature InGaAs PDs (the ones with reduced responsivity at 850 nm reported in [1])

Reactions to wide band PMD proposal of [2]

- Action items that should be included in the ToDo list:
  - Demonstration of wide availability and multiple providers for SWDM PDs
    - Name of providers
    - Data-sheets and samples availability in the same terms of InGaAs PDs
  - Provide technical information about SWDM PDs:
    - Technology used to overcome the limitations of conventional GaAs and InGaAs photodiodes
    - Internal structure and identification of failure modes for reliability assessment
    - PVT characterization between -40 and +125ºC
    - Reliability model and qualification report according to automotive mission profiles
  - Provide relative cost comparison of SWDM PDs vs. standard InGaAs PIN photodiodes

Reactions to wide band PMD proposal of [2]

- By specifying the receiver has to be sensible between 840 and 990 nm, it precludes flip-chip assembly option, which has been argued as advantageous for automotive application (see [1])
  - Standard die and wire bond assembly is more expensive than flip-chip specially when positioning accuracy is required
- What is the **value proposition of wide band PMD for automotive** application?
  - Validation, PVT characterization, qualification, PD's WS, and PHY FT are going to be more expensive, because reception along the full wavelength range have to be tested. Why more expensive devices, qualification and production tests would be good for automotive application?
  - A solution based on OM3 + 980nm VCSEL have been demonstrated to be optimal in terms of technical and economical feasibility and complete. Why does P802.3cz need a wide band PMD?
  - There is no backward compatibility requirements with 850nm in automotive application. We are free to choose the wavelength, specially because fiber link is limited to 40 meters. Why do we have to choose more than one wavelength?
  - How many single lane and no BiDi optical PHYs have been specified in 802.3 in this way?
    - Just 802.3dB? This is for data-center application project. 802.3cz is an automotive project.
    - The two rojects are targeted for different applications, so solutions need to be different.
  - Do we think market segmentation originated by multi lambda transmitters is positive for automotive?
  - Do we think OEM is going to be happy with the extra cost of supporting wide band PMD?
  - Most important: Are we solving a real OEM necessity with wide band PMD proposal?

Situation analysis

- If wide band PMD is finally the only solution for 802.3cz, then it will mean that consensus was not possible and we failed as 802.3 project
- From several moths ago, the TF has not been able to choose a PMD and a wavelength (as many other projects did in the past)
- There are a lot of evidences that show that OM3 + 980nm VCSEL is economically and technically feasible, is the optimal solution and is complete. However, it seems that we want to make everyone in TF happy **except the OEMs and Tier 1s**
- The focus should be the end user, i.e. the OEMs and Tier 1s, and the real mission of the project
- The real mission is developing an amendment to IEEE Std 802.3 with specifications of a PHY fulfilling the project objectives and specific requirements of the application
  - operation temperature range,
  - automotive mission profiles,
  - high level of integration in ECUs,
  - very low cost per link
- With the current situation of the project we have a very high probability of making a Frankenstein specification without really attending to the application and the end user
- We could accept anything in this project. However, we should think on the price that we are going to pay.
  - Will the market adopt multiple wavelengths transmitters?
  - Will the market adopt wide band PMD w/o justification of the extra costs?
- The reality in the market will be implementations that only support one wavelength in TX and RX, and none of them will be 100% compatible with 802.3cz

Considerations on WG/SA ballots

- Ethernet is successful in the market because 802.3 specifies interoperability standards of equipment that implements
    1. **solutions defined by the applications**, and
    2. only **one** solution per application (data-rate, medium, link reach)
- Although 802.3 does not specify implementations (e.g. VCSEL, CMOS, Si-Photonics, InGaAs PD) because they are not needed for interoperability definition, 802.3 uses them to define solutions and to write standards that **are realistic, implementable by many providers, and can satisfy the end user expectations**
- That means that in the **specification development** we have to **take into account a solution** that meet every **requirement of the application** and all the **project objectives**
- In case of having several potential solutions, **only one** should be chosen as the best one regarding to CSD responses
- During WG and SA ballots, consistency of 802.3cz draft according to previous points is going to be verified
- **The proposal of wide band PMD (840nm ~ 990nm) seems to be a single solution for the automotive application, however it is not single and is against the application and the end user**

References

- [1] R. Perez-Aranda, “Holistic approach for VCSEL wavelength selection,” July 2021, [Online], Available: https://www.ieee802.org/3/cz/public/jul_2021/perezaranda_3cz_01_0721_wavelength.pdf
- [2] R. Murty, “A Single PMD to Cover 840 – 990 nm with OM3 fiber,” July 2021, [Online], Available: https://www.ieee802.org/3/cz/public/jul_2021/murty_3cz_01_072021.pdf

Thank you