Eye safety requirements for 802.3cz

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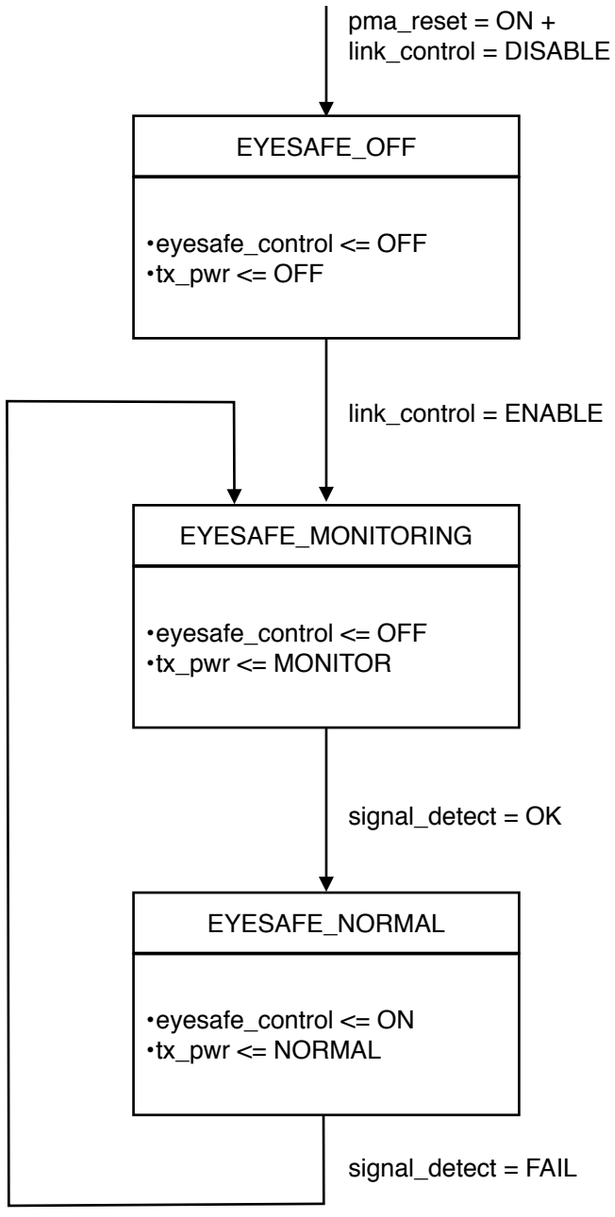
Introduction

- Eye safety is key for automotive applications
  - Even if these connections are “under the hood”, it could be easy for any non-trained car user to unplug a connection and be exposed to the laser radiation
  - To avoid any labelling and additional precautions, either the Laser Class 1 or Laser Class 1M should be achieved per IEC 60825. Laser Class 1M is as Class 1 without including optical instruments for intra-beam viewing
- Eye safety requirement
  - In other automotive optical communications networks, i.e. MOST and GEPOF, Laser Class 1 is a requirement
  - nGBASE-AU transceivers should meet Laser Class 1
- In [1], AOP (Average Optical Power) measurements at TP1 were presented for several characterized VCSELs in cold, room and hot temperatures
  - Big AOP differences due to wide operation range were reported
- Based on realistic optical coupling design, AOP at MDI, TP2 and TP3 were calculated for BC (butt-coupling) and EBO (expanded beam optics) connectivity
- Eye-safety limits were calculated for Class 1 and Class 1M considering BC and EBO
- It was concluded that BC meets the Class 1 limits, but EBO needs of additional steps
- A simple general method for eye safety control was proposed that allows to meet eye-safety limit regardless the used optical connectivity, BC or EBO
  - Transceiver and inline connectors **have to be duplex** to ensure that both transmission paths of the link are opened at the same time by design

Eye safety control method — description



- **eyesafe_control:** variable set by the PMA eye safety control state diagram to control the operation of the PMA TX and RX.
  (Modify PHY TX control and PHY RX control state diagrams to respond to open-ended eyesafe_control = OFF)
  Values:
  - OFF: PMA is disabled
  - ON: PMA is enabled
- **tx_pwr:** controls the PMD transmitter power.
  Values:
  - OFF: PMD TX does not generate optical signal (AOP_{TP2} = 0 mW)
  - MONITOR: PMD TX generates optical signal with AOP_{MDI} that shall meet eye safety limits and AOP_{TP2} higher than a threshold ($AOP_{TP2\text{-}MIN}$) to guarantee signal_detect = OK is produced in the link partner
  - NORMAL: PMD TX generates optical signal as needed for reliable link operation and that may overpass the eye-safety limits
- **signal_detect:** parameter set by PMD signal detect function indicating whether the PMD is detecting average optical power over a threshold at the receiver or not.
  - OK: PMD is detecting average optical power over a threshold
  - FAIL: PMD is detecting average optical power below a threshold

Eye safety control method — parameters

- Signal detect thresholds (PMD signal detect function):
  - $AOP_{TP3\text{-}WU}$ (TBD): if $AOP_{TP3} > AOP_{TP3\text{-}WU}$, then the parameter signal_detect = OK
  - $AOP_{TP3\text{-}SD}$ (TBD): if $AOP_{TP3} < AOP_{TP3\text{-}SD}$, then the parameter signal_detect = FAIL
  - For $AOP_{TP3\text{-}SD} \leq AOP_{TP3} \leq AOP_{TP3\text{-}WU}$, the value of signal_detect is unspecified (uncertainty range)
- $AOP_{TP2\text{-}MIN}$ (TBD): the min AOP at TP2 to guarantee signal_detect = OK in the link partner considering the max insertion loss of the channel
- $t_{TX\text{-}NORMAL\text{-}to\text{-}MON\text{-}MAX}$ (TBD): max time between signal_detect OK to FAIL transition and tx_pwr NORMAL to MON transition
  - It is implementable to be < 100 µs.

Eye safety control — illustrative example

- Implementation of the described eye safety control is illustrative
- Some PHYs may meet eye safety limits without specific counter-measurements implementation
- Some implementations may implement mechanical counter-measurements at connector level, e.g. transceiver and inline connections with shutters, one-time locked connectors, …

- **This method explained in this contribution illustrates how is possible to meet the eye safety limits regardless the optical connectivity is used**

Eye safety requirements for nGBASE-AU

- Any nGBASE-AU optical transceiver **shall meet eye safety limits**
- Specification of this optional method does not preclude optical safety sub-clause
  - nGBASE-AU optical transceivers shall conform to Hazard Level 1 laser requirements as defined in IEC 60825-1 and IEC 60825-2, under any condition of operation. This includes single fault conditions whether coupled into a fiber or out of an open bore.
  - Conformance to additional laser safety standards may be required for operation within specific geographic regions.
  - Laser safety standards and regulations require that the manufacturer of a laser product provide information about the product's laser, safety features, labeling, use, maintenance, and service. This documentation explicitly defines requirements and usage restrictions on the host system necessary to meet these safety certifications.

References

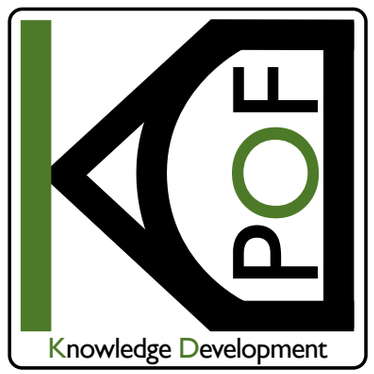
- [1] R. Pérez-Aranda, “Eye safety analysis for 802.3cz links,” December 2020, [Online], Available: https://www.ieee802.org/3/cz/public/22_dec_2020/perezaranda_3cz_01_221220_eyesafety.pdf

Motion

- Move to adopt eye safety requirements for nGBASE-AU in slide 6 of perezaranda_3cz_02a_260121_eyesafety.pdf

- Move: Rubén Pérez-Aranda

- Second: David Law



Thank you!