Link budget requirements for Gigabit Ethernet over Plastic Optical Fiber

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Agenda

- Objectives
- Assumptions for link budget
- Automotive requirements
- Consumer requirements
- Conclusions

Disclaimer

- This presentation does not provide a complete list of requirements for a Gigabit Ethernet POF PHY, but only the necessary to address the link budget analysis

Objectives

- To make a proposal of the receiver sensitivity requirements under worst-case conditions of the optical link budget for Gigabit Ethernet over POF for two technology applications:
  - Automotive market
  - Consumer market

- Worst-case receiver sensitivity requirements are going to be the base for technical feasibility study based on Shannon's channel capacity

Assumptions for link budget

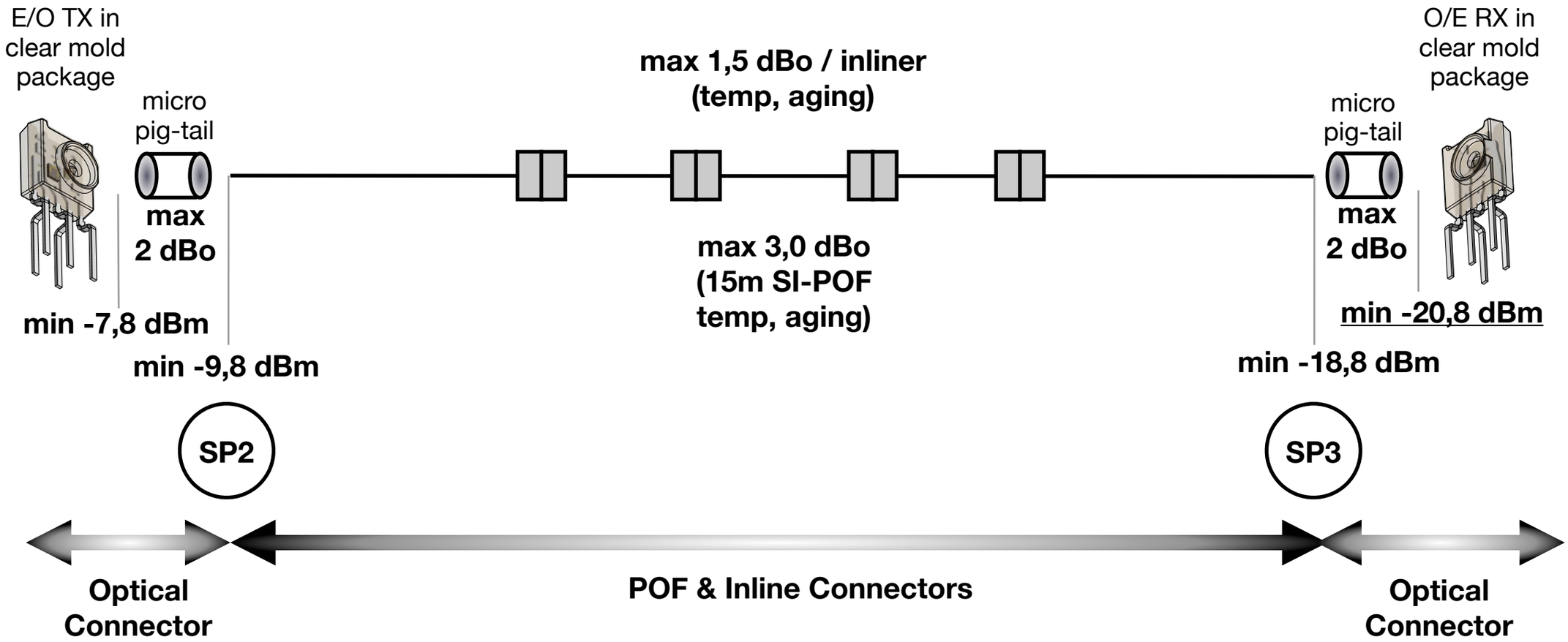
- For automotive application
  - Same light source (i.e. red LED) qualified for automotive MOST150 application is used
  - Same Plastic Optical Fiber (POF) used in MOST150 applications is used
  - Both previous assumptions allow to make the link budget analysis based on 15 years of experience in millions of real installations
  - Similar requirements to RTPGE are assumed in terms of link segment length and number of inline connectors, because these requirements were agreed by OEMs
  - Worst-case conditions of temperature and aging of optical components in the car will be considered

- For consumer applications
  - It is developed based on the requirements for automotive applications, but operational conditions and aging specifications are relaxed accordingly
  - Same light source is used in a shorter temperature range
  - Same fiber is used in terms of core and cladding, as typically happens, although jacket is cheaper

Automotive requirements

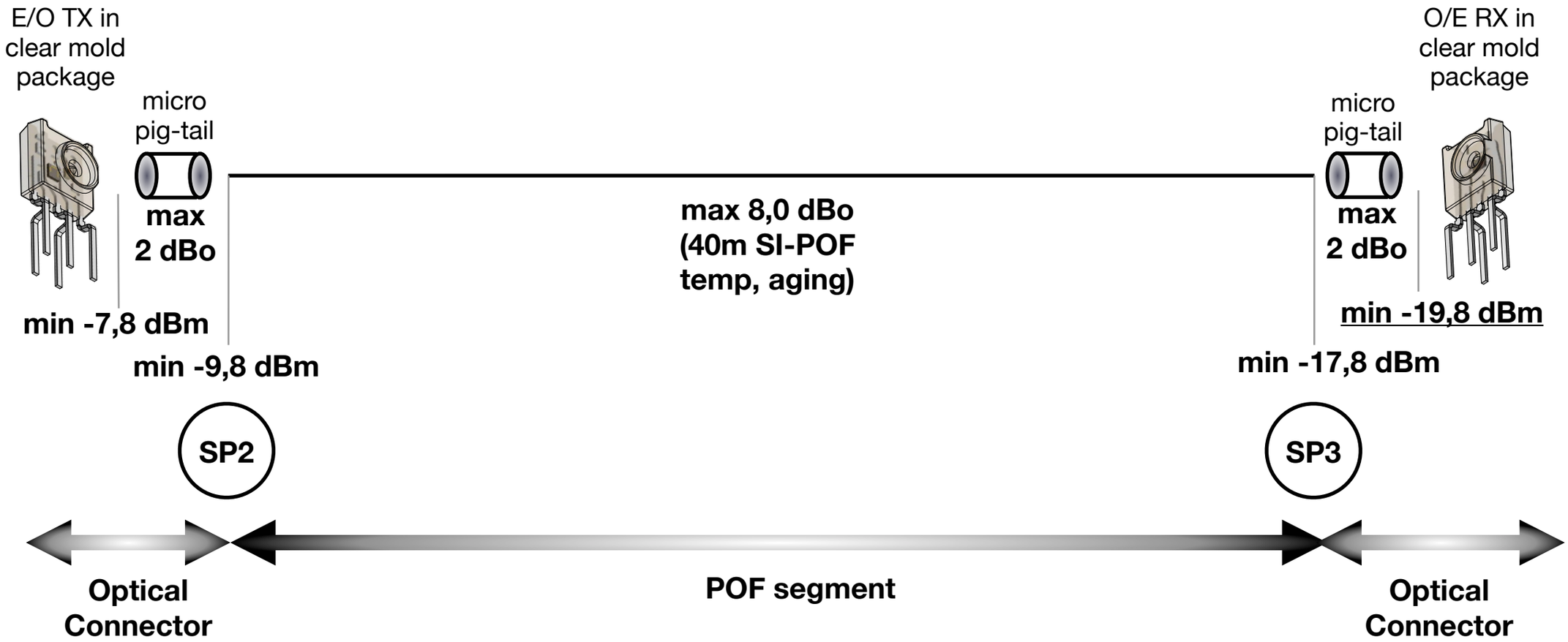
Requirement	Value	Additional/Comments
Max. link segment length	15 m for passenger vehicles with inline connectors	40 m for commercial vehicles without inline connectors
Max. number of inline connections	4 inline connectors	
Bit Error Rate (BER) at GMII RX	$< 10^{-12}$	
Ambient temperature range of operation	-40 .. +95°C	

Automotive link budget: 15 meters + 4 inliners



- Red LED: AOP max. 1,5 dBm, min -7,8 dBm in temperature range, aging and optical alignment tolerances. ER min. 8 dB, max 12 dB
- Fiber attenuation: max. 0,2 dBo/meter considering aging under EMD launching condition ➤ 3 dBo for 15 m
- Inliner attenuation: max. 1,5 dBo / inliner in temperature and aging ➤ max. 6 dBo for 4 inliners
- **RX sensitivity requirement for max. temperature and aging: -20,8 dBm**

Automotive link budget: 40 meters



- Red LED: AOP max. 1,5 dBm, min -7,8 dBm in temperature range, aging and optical alignment tolerances. ER min. 8 dB, max 12 dB
- Fiber attenuation: max. 0,2 dBo/meter considering aging under EMD launching condition ➤ 8 dBo for 40 m
- **RX sensitivity requirement for max. temperature: -19,8 dBm**

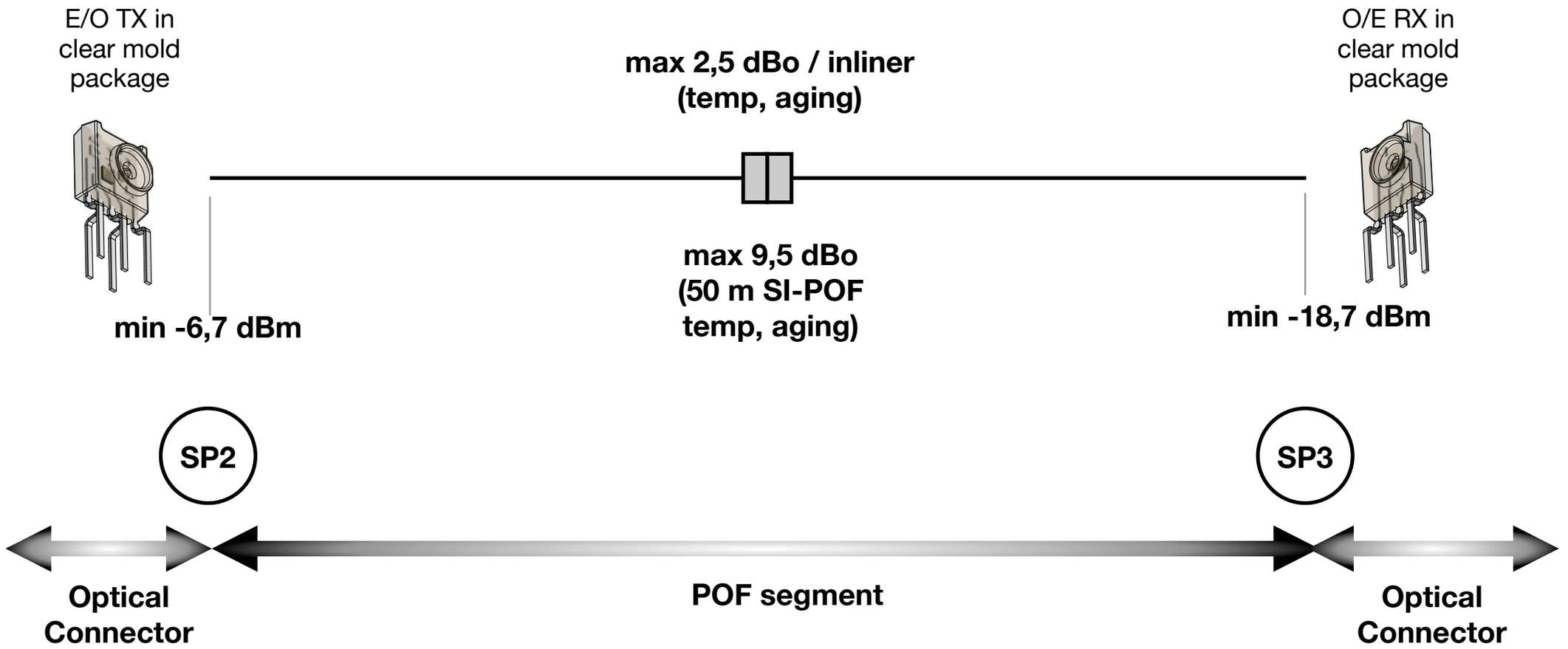
Automotive link budget: extension up to 105ºC

- Optical components for automotive have been qualified up to +95ºC until now because MOST150 was defined for infotainment, and previous link budget analysis has been provided for this temperature range
- Here is presented a preliminary extension to +105ºC.
  - A priori there is no technical reasons limiting the feasibility at 105ºC
  - Optical component manufacturers have to confirm the feasibility
- Launched optical power of MOST150 devices is reduced down to min. -8.5 dBm for 105ºC
- RX sensitivity requirements has to be modified accordingly:
  - 15 m segment + 4 inliners ➤ **-21.5 dBm**
  - 40 m segment w/o inliners ➤ **-20.5 dBm**
- Open topics for task force:
  - LED reliability; life time under automotive temperature profile up to 105ºC
  - High temperature POF for 105ºC: aging characterization, AC response, max. attenuation, jacket, …
  - Aging characterization of inliner connectors, to establish max. attenuation.

Consumer requirements

Requirement	Value	Additional/Comments
Max. link segment length	50 meters	
Max. number of inline connections	1 inliner	
Bit Error Rate (BER) at GMII RX	$< 10^{-10}$	
Ambient temperature range of operation	0 .. +85 °C	To allow integration into a wall plug or similar device with restricted air flow and no heat sink

Consumer link budget: 50 meters



- Red LED: AOP max. -1 dBm, min -6,7 dBm in temperature range, aging and optical alignment tolerances. ER min. 8 dB, max 12 dB
- Fiber attenuation: max. 0,19 dBo/meter considering aging under EMD launching condition ➤ 9,5 dBo for 50 m
- Inliner attenuation: max. 2,5 dBo / low cost inliner in temperature and aging
- **RX sensitivity requirement for max. temperature: <u>-18,7 dBm</u>**

Conclusions

- A baseline of requirements for Automotive and Consumer applications of GEPOF have been provided
- Based on these requirements, a link budget analysis have been carried out, to extract the receiver sensitivity to fulfill the requirements
- Shannon's capacity analysis should be based on these requirements to establish the technical feasibility

Questions?