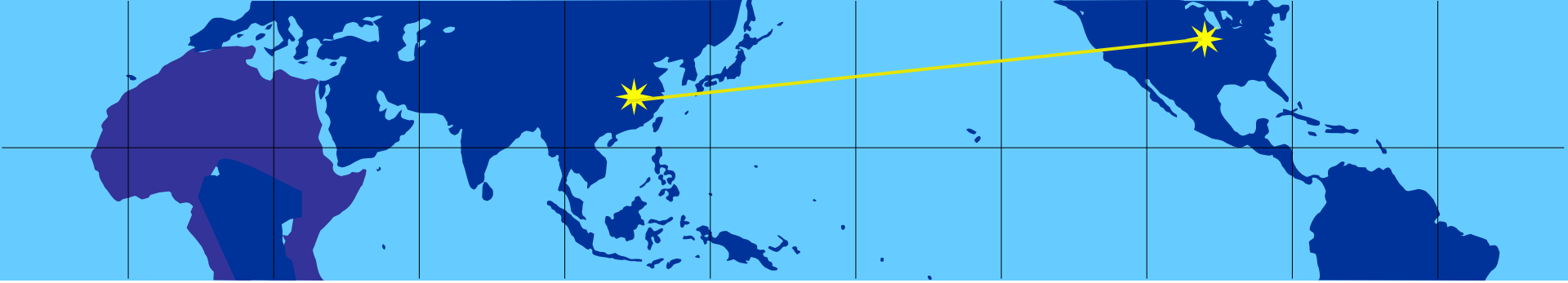

Current Status of the 10G-EPON Power Budget and Improvement

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- David Li, Ligent Photonics
- Frank Chang, Vitesse Corp.
- Marek Hajduczenia, ZTE Corp.

Outline

- Technical status of the EPON PMDs
- 10G-EPON deployment scenario
- Current status of the power budget in EPON and 10G-EPON
- Power budget Improvement for the extended 10G-EPON
- Summary

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Technical Status of EPON PMDs

- 1G-EPON PMDs have been deployed in tens of millions since 802.3ah was released in 2004. The 1G-EPON modules are available from many suppliers.

- 10G-EPON PMDs are available from several manufacturers. Such devices were considered state of the art when 802.3av-2009 was released.

- Link budget improvement and development of EPON transceivers has not stopped. The focus of new developments is on improving launch power and better sensitivity from the 1G and 10G PMD transceivers.

New Demand on Link Budget – for actual deployment

2008 → 2011

EPON	>PX-20	PX-20+	PX-20++	
GPON	Class B+	Class C	Class C+	Class C++
10G-EPON	>PR-20	PR-30	“PR-40”	“PR-50”
NG-PON1	N1	N2	E1	E2
Split Ratio Target	1:32	1:64	1:128	1:256
Link Budget (dB)	29.5~30	31.5~32	33.5~34	35.5~36

- Higher splitting ratio and longer reach is in demand.
- New technology and high performance devices are required for the new application

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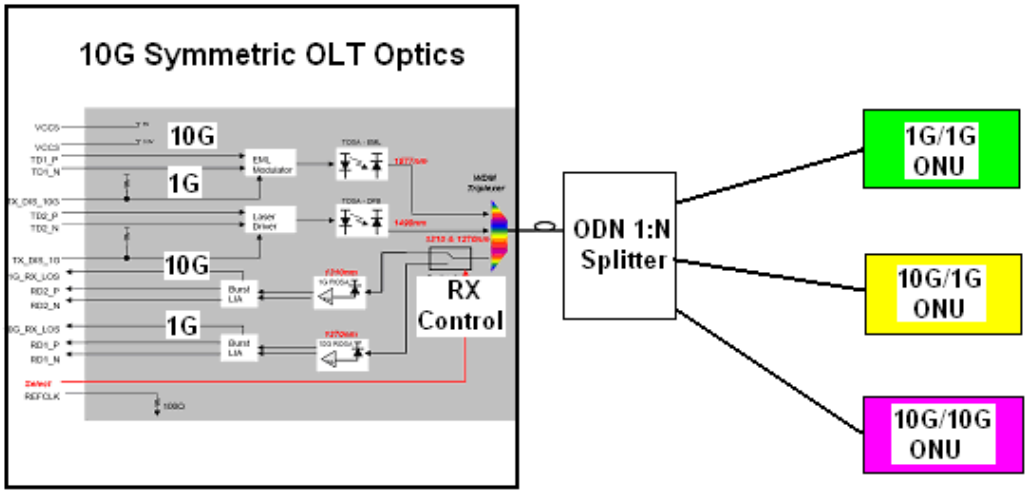
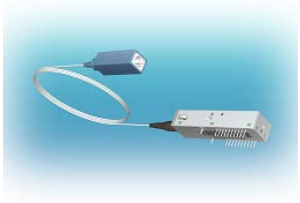
10G-EPON Deployment Scenario

- In Asia, the 10G-EPON is mainly deployed for quad-wavelength or Tri-wavelength applications



Quad-wavelength Symmetric OLT

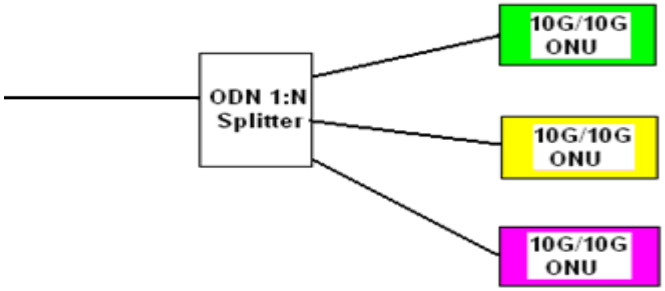


SFF ONU

SFP+ ONU

- In US, the 10G-EPON is mainly preferred for dual wavelength symmetric applications

XFP OLT



SFP+ ONU

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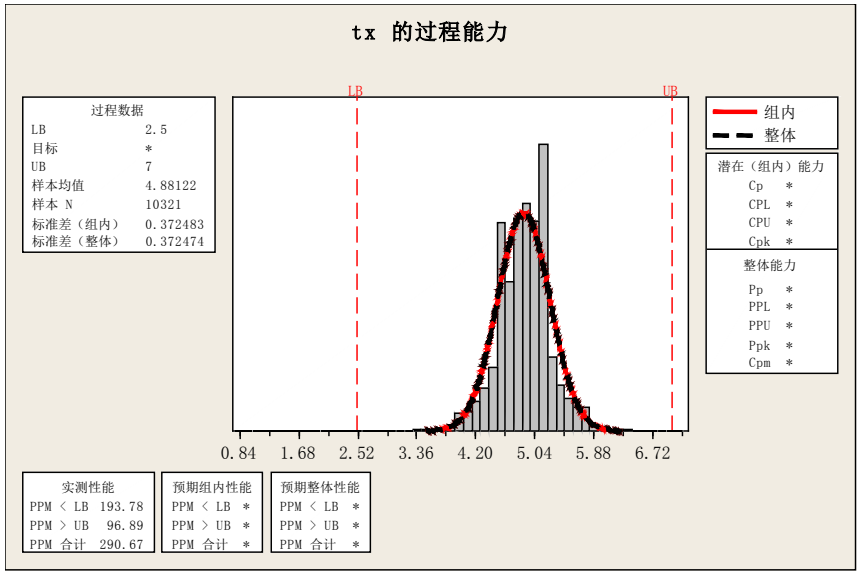
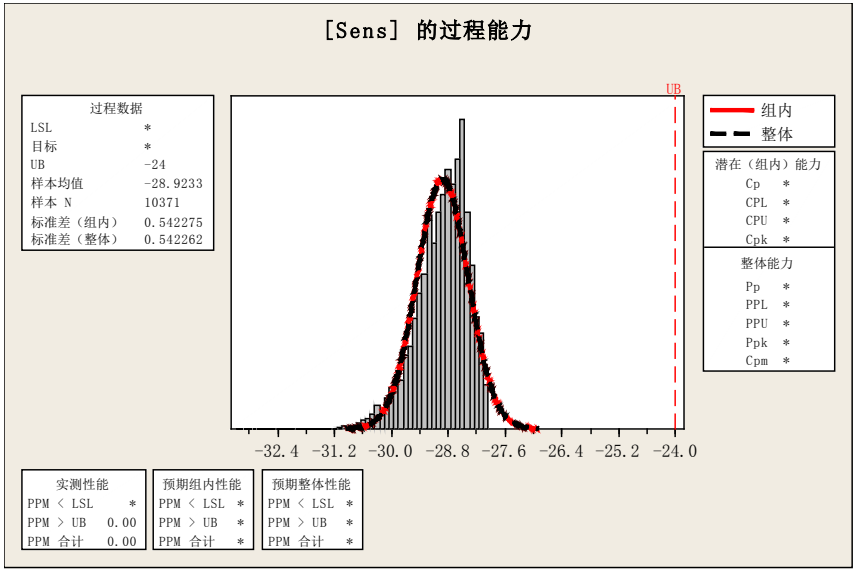
Current Status (1G-EPON)

1G-EPON PMD Downstream Link

1G-EPON OLT TX Power (10521pcs)



1G-EPON ONU RX Sensitivity (10571pcs)



	TX Power	Rx Sensitivity	Link Budget
IEEE802.3ah PX20	+2dBm	-24dBm	26dB
Actual Min	+3dBm	-28dBm	31dB
Actual Typical	+4.5dBm	-29dBm	33.5dB

- Current 1G-EPON modules can support for 31 dB downstream link budget
- 1G-EPON could also support for higher power budget classes at least to 33-34dB, by tuning the components and tight the pass/fail criteria.

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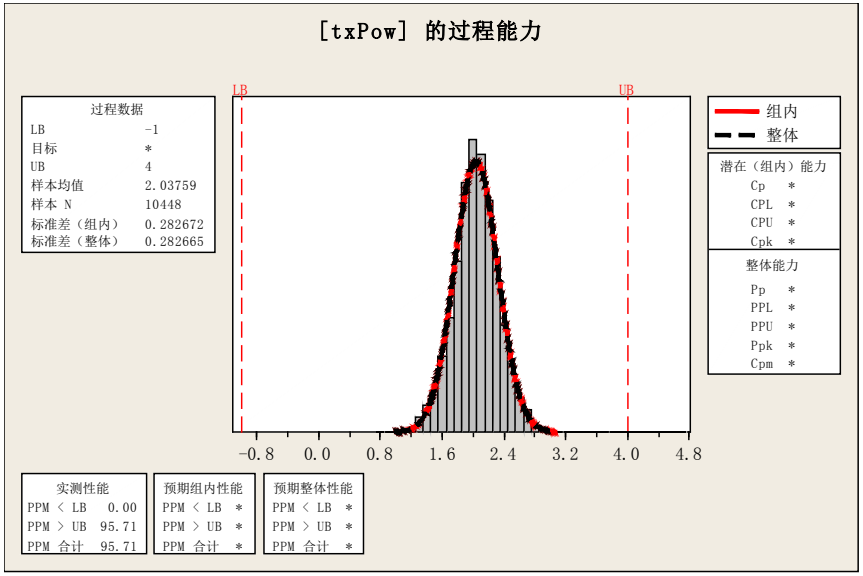
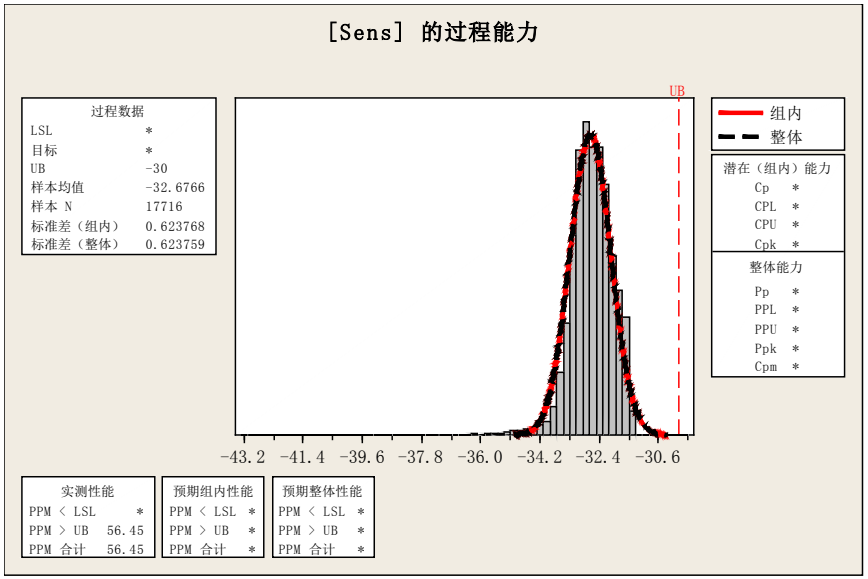
Current Status (1G-EPON)

1G-EPON PMD upstream link

1G-EPON ONU TX Power (10448pcs)



1G-EPON OLT RX Sensitivity (17716pcs)



	TX Power	Rx Sensitivity	Link Budget
IEEE802.3ah PX20	-1dBm	-27dBm	26dB
Actual Min	+0.5dBm	-30.5dBm	31dB
Actual Typical	+2.0dBm	-32.5dBm	34.5dB

- Current 1G-EPON modules can support for 31 dB upstream link budget.
- 1G-EPON could also support for higher upstream power budget classes to 34-35dB, by tuning the components and tight the pass/fail criteria.

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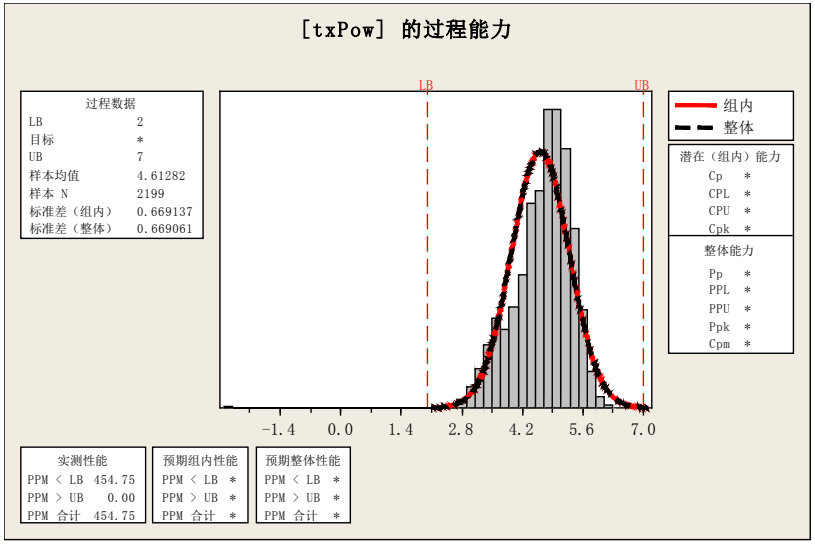
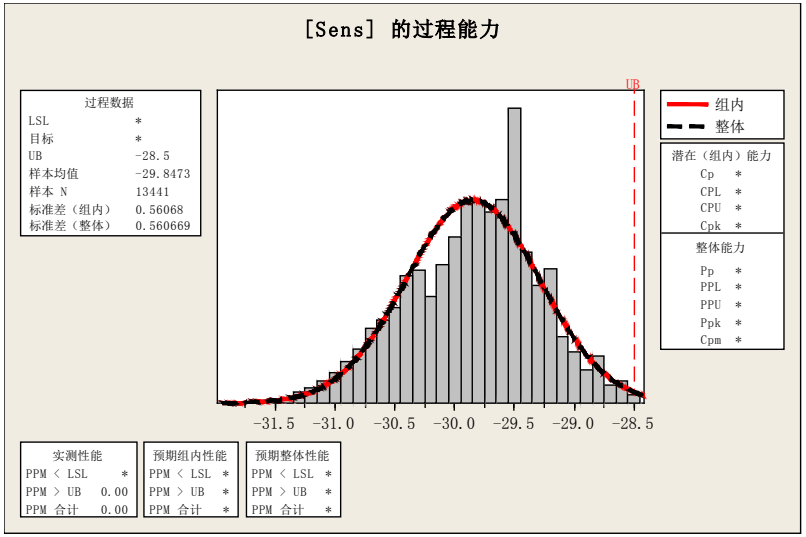
Current Status (10G-EPON)

10G-EPON Downstream

10G-EPON OLT TX Power (2199pcs)



10G-EPON ONU RX Sensitivity (15441pcs)



	TX Power	Rx Sensitivity	Link Budget
IEEE802.3av PR30	+2dBm	-28.5dBm	30.5dB
Actual Min	+2dBm	-28.5dBm	30.5dB
Actual Typical	+5dBm	-30dBm	35dB

- Current 10G-EPON modules can support for 30.5dB downstream link budget, as defined in 802.3av (PR30).
- 10G-EPON could also support for higher downstream power budget classes up to 35dB, by tuning the components and tight the pass/fail criteria.

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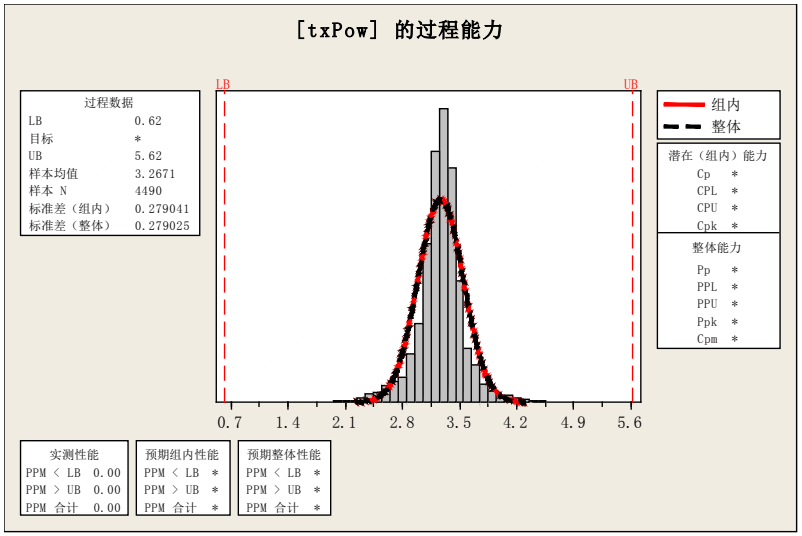
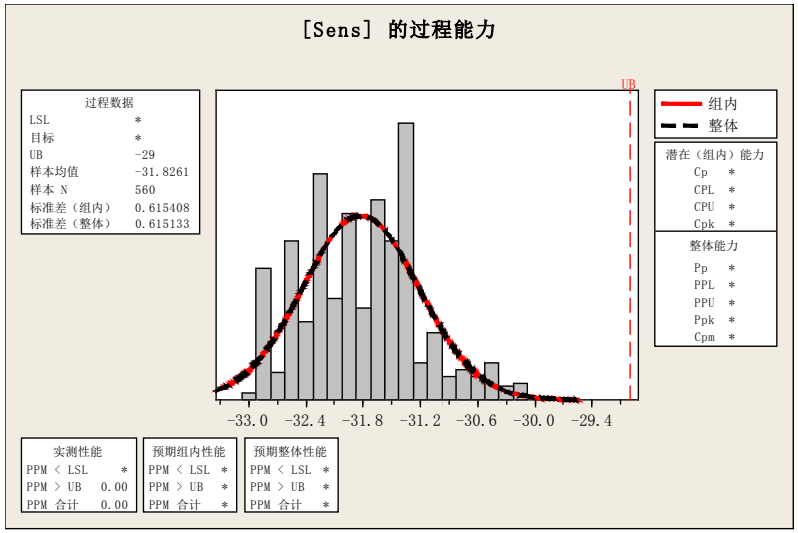
Current Status (10G-EPON)

10G-EPON Asymmetric Upstream

10G-EPON Asymmetric ONU TX (4490pcs)



10G-EPON Asymmetric OLT RX (560pcs)



	TX Power	Rx Sensitivity	Link Budget
IEEE802.3av PRX30	+0.65dBm	-29.78dBm	30.4dB
Actual Min	+2dBm	-30dBm	32dB
Actual Typical	+3.5dBm	-32dBm	35.5dB

- Current 10G-EPON PRX-30 modules can support for 32 dB upstream link budget, as defined in 802.3av-2009.
- 10G-EPON could also support for higher upstream power budget classes up to 35.5dB, by tuning the components and tight the pass/fail criteria.

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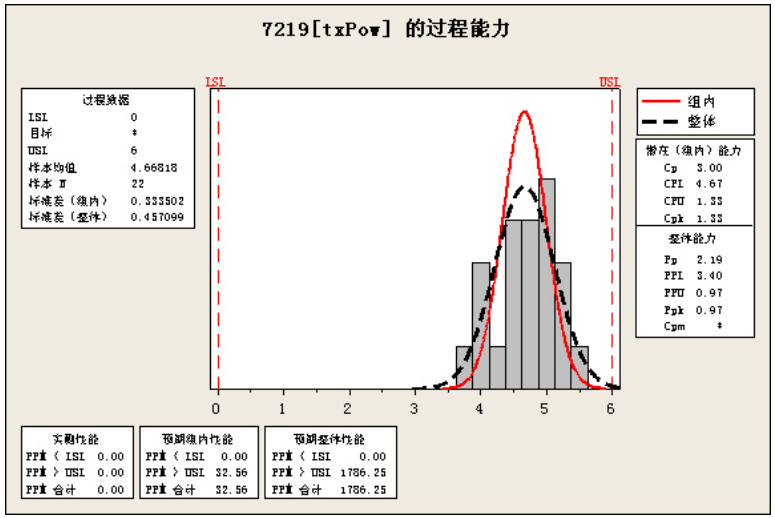
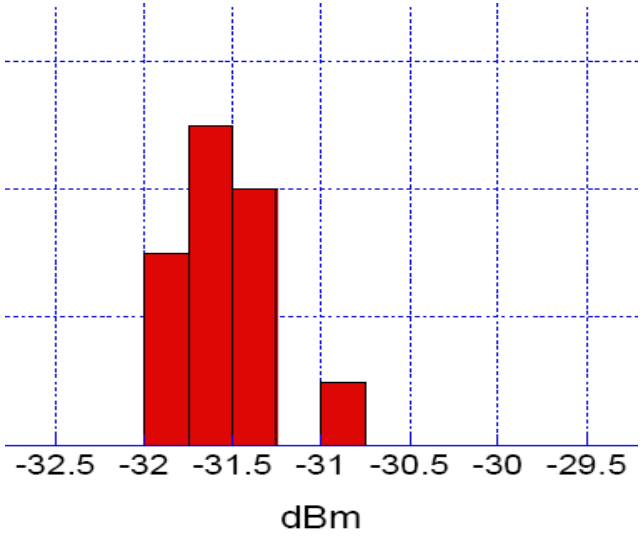
Current Status (10G-EPON)

10G-EPON Symmetric Upstream

10G-EPON Symmetric ONU TX (22pcs)



10G-EPON Symmetric OLT RX (lab test data)



	TX Power	Rx Sensitivity	Link Budget
IEEE802.3av PR30	+4dBm	-28dBm	32dBm
Actual Min	+4dBm	-29dBm	32dBm
Actual Typical	+5dBm	-30dBm	35dBm

- Current 10G-EPON PR-30 modules can support for 32 dB upstream link budget, as defined in 802.3av-2009.
- 10G-EPON could also support for higher upstream power budget classes, up to 35dB.

Power Budget Improvement

There are multiple ways of reaching higher power budget

- Increase transmitter launch power (improved lasers, external / internal amplifiers)
- Increase receiver sensitivity (improved receiver sensitivity, preamplifier)
- Include in-line amplification (reach extender) providing optical or OEO amplification for passing data streams
- Decrease the ODN loss (lower loss fiber, improved splitter design etc.)

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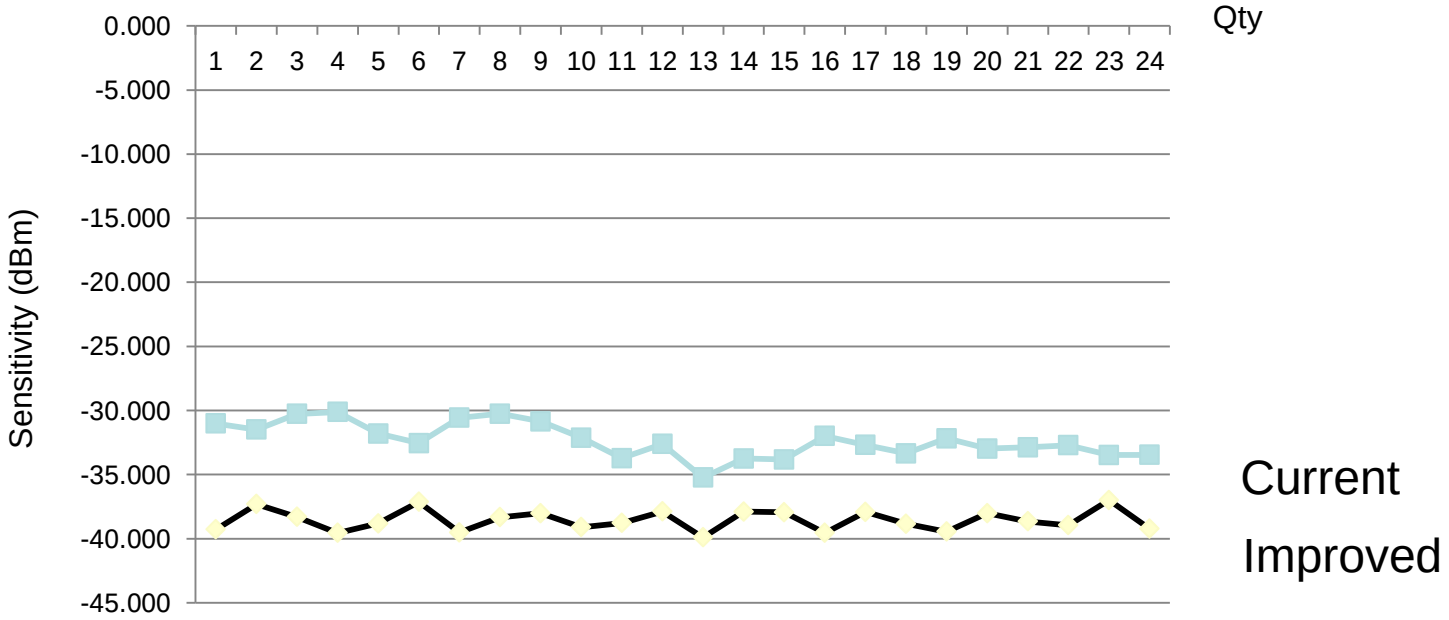
Power Budget Improvement on the OLT

Improvement in the 10G Asymmetric OLT RX Sensitivity

The OLT receiver sensitivity can be improved by optimizing the circuit



- The 10G-EPON asymmetric OLT receiver sensitivity can be improved from current -32.5dBm (average) to -37.5dBm.

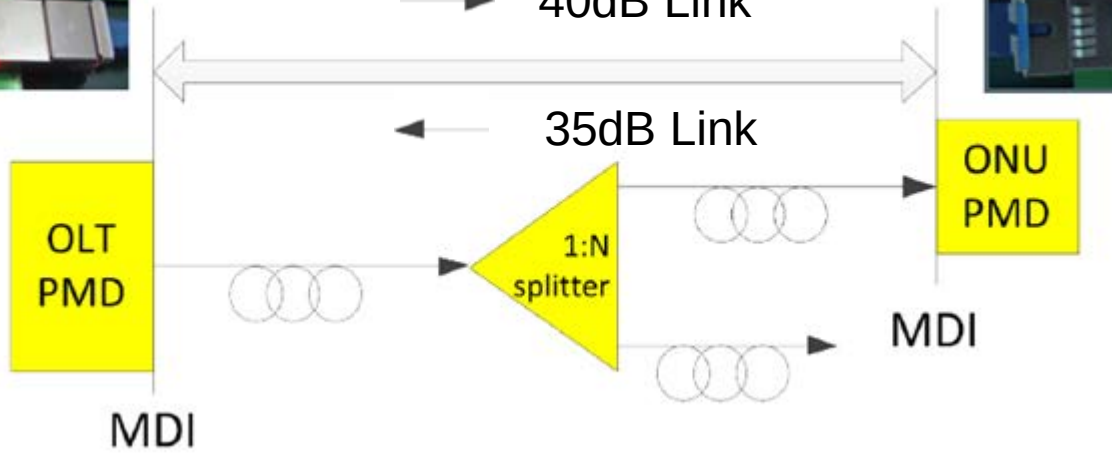
- The 10G-EPON symmetric OLT receiver sensitivity may be improved by optimizing the trans-impedance amplifier, adding pre-amplifications, or using the low loss mode conversion receiver.

Power Budget Improvement (10G OLT TX Power)

Recent Improvement on the 10G Symmetric OLT TX Power

TX: +11dBm
RX: -29dBm

TX: 5dBm
RX: -29dBm



- The 10G-EPON symmetric OLT TX power is improved from +5dBm to +11dBm. With the off the shelf 10G-EPON ONU, available power budget is 40dB in the downstream link.

- The upstream link budget is about 35dB now, which can be improved further by adding preamplifier.

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Summary

- The demand for link budget in the current 1G-EPON deployment far exceeds the original IEEE802.3ah spec.

- Based on the current component manufacturing technology, the 1G-EPON and 10G-EPON PMDs can support 33dB~35dB link budgets without dramatic changes in the manufacturing process and materials.

- It is suggested that the link budget of the extended 10G-EPON PMDs can be set as 37dB, in compliance with the FSAN 987.2 NG-PON1 E2 spec.

- To reach 37dB downstream link budget, the OLT TX power in the 1G-EPON and 10G-EPON can be increased by adding amplification with low cost solution.

- To reach 37dB upstream link budget, the OLT RX sensitivity in the 1G-EPON can be improved to -35dBm~-37dBm with the available technology.

- To reach 37dB upstream link budget in the 10G-EPON, the OLT RX sensitivity can be improved by using low loss receiver.