Cost Analysis of Tunable WDM-PON Transceivers

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Content

- PMD requirements in Super-PON
- WDM transceivers with tunable lasers
- Cost analysis

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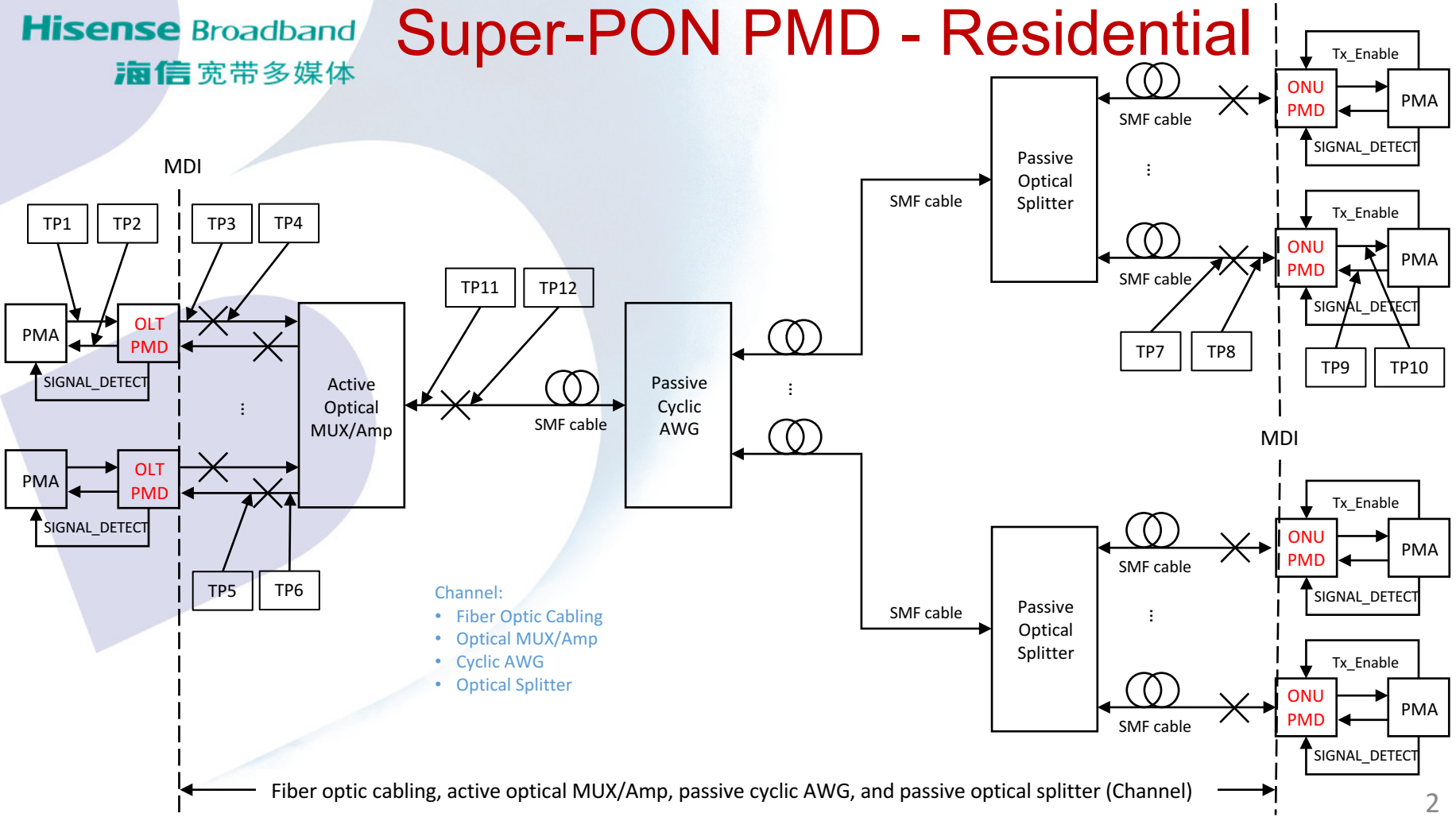
Super-PON PMD - Residential



Channel:

- Fiber Optic Cabling
- Optical MUX/Amp
- Cyclic AWG
- Optical Splitter

Fiber optic cabling, active optical MUX/Amp, passive cyclic AWG, and passive optical splitter (Channel)

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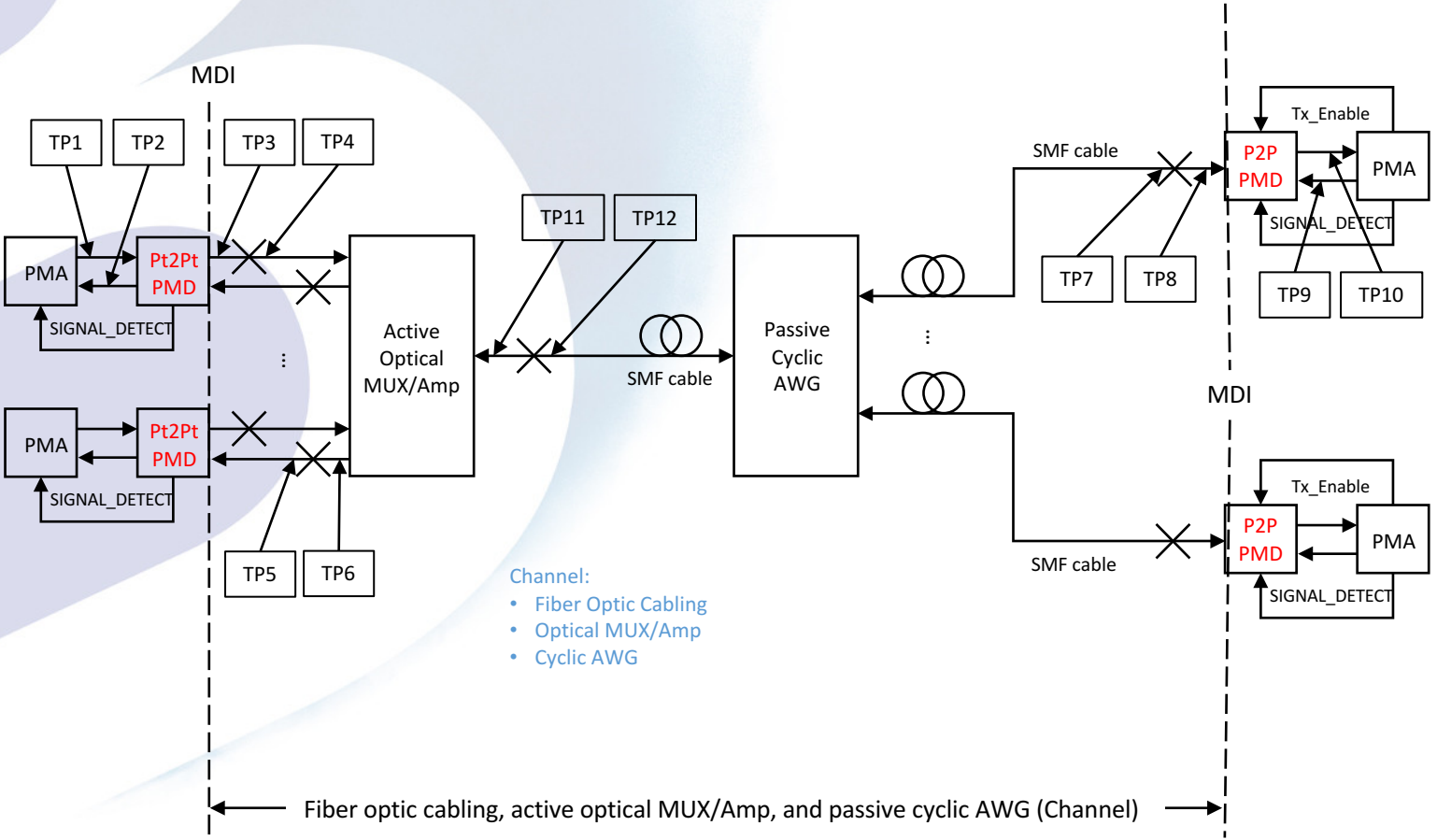
Super-PON PMD – P2P



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Residential PMD Requirements

OLT	Super-PON	TDM PON
TX	Continuous mode, DWDM L-band	Continuous mode, 1490 nm or 1577 nm
RX	Burst mode	Burst mode
TX Power	relaxed, with amplification	Defined by IEEE802.3-2015 ITU984 and 987
RX sensitivity	Same as TDM PON	Defined by IEEE802.3-2015 and ITU984 and 987

ONU	Super-PON	TDM PON
TX	Burst mode, DWDM C-band, optionally tunable	Burst mode, 1310 nm, 1270 nm
RX	Continuous mode	Continuous mode
TX Power	Same as TDM PON	Defined by IEEE802.3-2015 and ITU984 and 987
RX sensitivity	Same as TDM PON	Defined by IEEE802.3-2015 and ITU984 and 987

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P2P PMD Requirements

P2P OLT	Super-PON	TDM PON	DWDM module
TX	Continuous mode, DWDM L-band	Continuous mode	Continuous mode, DWDM C-band
RX	Continuous mode	Burst mode	Continuous mode
TX Power	relaxed, w/o splitter loss	Defined by IEEE802.3-2015 and ITU984 and 987	0-4 dBm
RX sensitivity	Same as TDM PON	Defined by IEEE802.3-2015 and ITU984 and 987	-24 dBm

P2P ONU	Super-PON	TDM PON	DWDM module
TX	Continuous mode, DWDM C-band, optionally tunable	Burst mode, 1310 nm or 1270 nm	Continuous mode, DWDM C-band
RX	Continuous mode	Continuous mode	Continuous mode
TX Power	relaxed, w/o splitter loss	Defined by IEEE802.3-2015 and ITU984 and 987	0-4 dBm
RX sensitivity	relaxed, w/o splitter loss	Defined by IEEE802.3ae, av and ITU984 and 987	-24 dBm

Tunable Technology

Why we need the Tunable Technologies for WDM application?

Pros:

- The tunable modules are much easier to be installed in the field in the WDM system
- Inventory and operational cost is much lower than fixed

Cons:

- Initial module cost is higher than that of the fixed wavelength module

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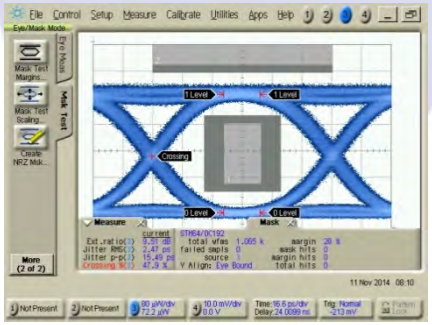
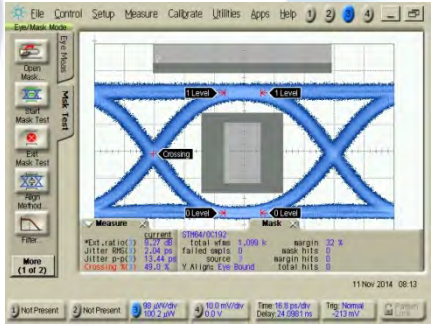
10G L-band OLT Performance

	OP(dBm)	ER(dB)	Margin(%)	Wavelength	SEN
CH1	7.95	9.51	28	1596.342	-30.5
CH2	7.87	9.27	32	1597.197	-30.3
CH3	7.65	9.68	31	1598.041	-30.8
CH4	7.54	9.6	28	1598.892	-30.6

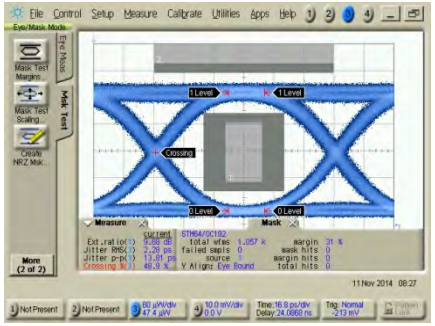
CH1



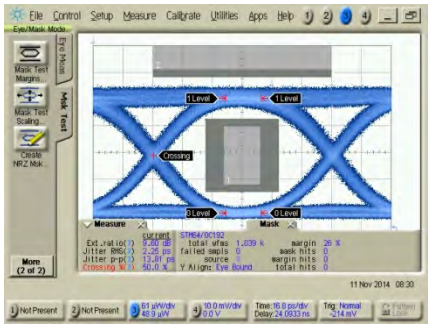
CH2



CH3



CH4



L-band devices with fixed wavelength EML lasers are available.

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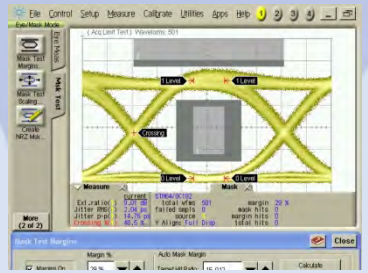
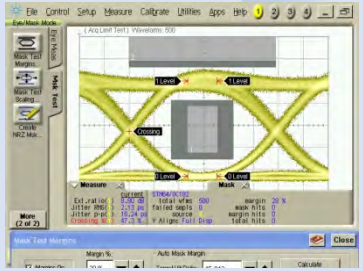
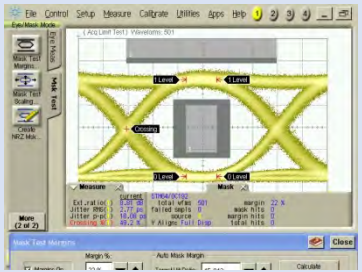
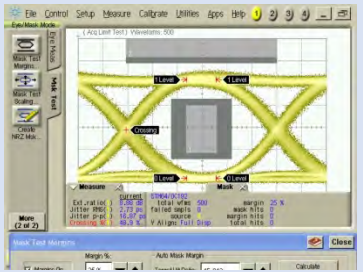
10G C-band ONU Performance

		OP(dBm)	ER(dB)	Margin(%)	I_VCC	TEC_T(℃)	I_BIAS(mA)	I_MOD(mA)	I_SOA(mA)
D6E031101 (25℃)	CH0	7.98	9.01	29	863	39	68	69	269
	CH1	7.20	8.80	28	727	47	75	53	230
	CH2	6.34	8.81	22	725	55	82	58	217
	CH3	6.53	8.88	25	735	60	123	57	184

CH0 **CH1** **CH2** **CH3**

C-band ONU modules with tunable wavelength lasers are available

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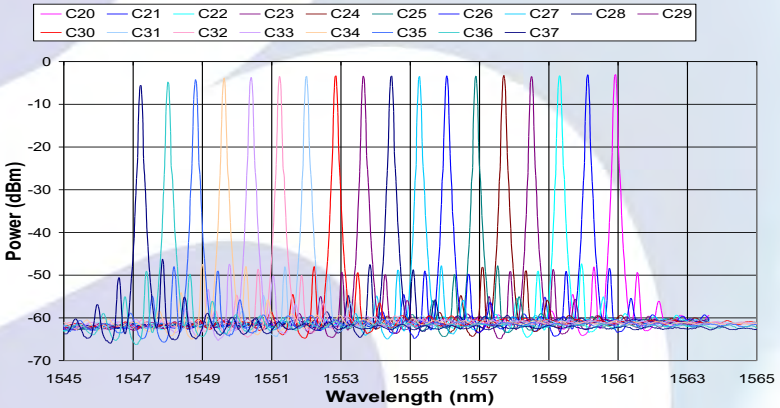
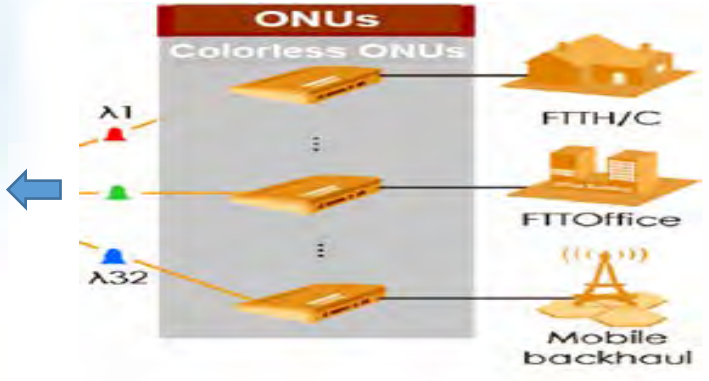
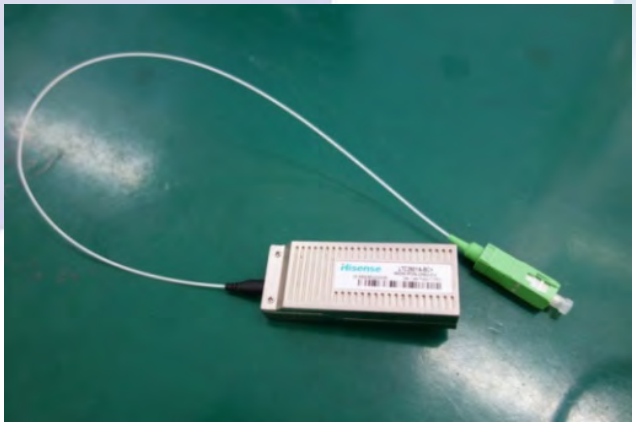
Single DBR Tunable Laser for ONU







Specification:

- Operating wave length：1524 - 1560nm
- Tuning range: >12nm
- Output power：>10mW
- Data rate：>10Gbps
- Can be tuned to cover 16 channels with 100G spacing

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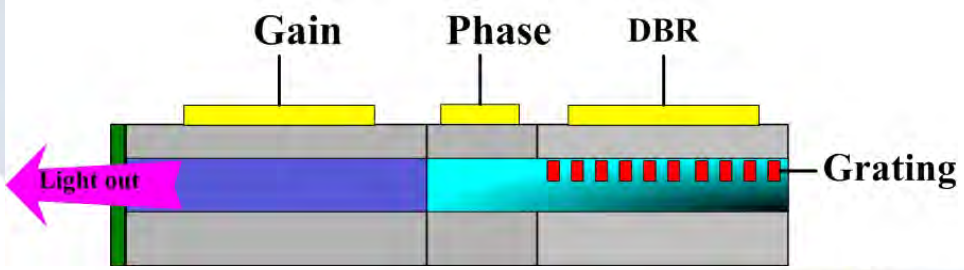
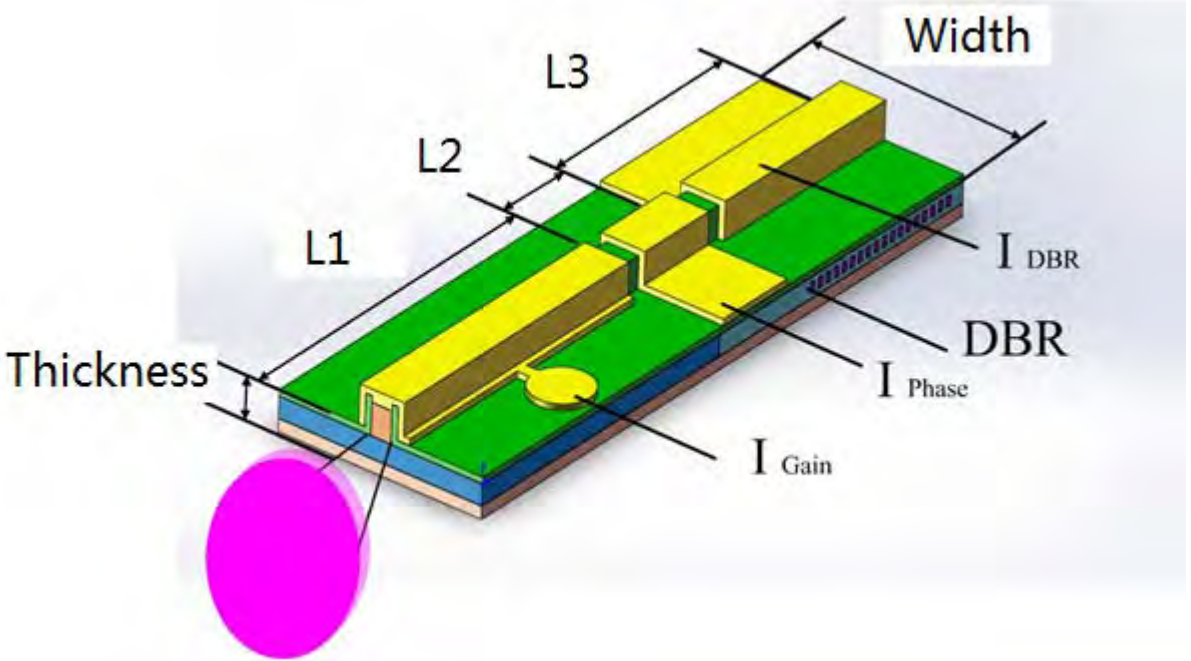
Single DBR Tunable Laser Structure

1. Similar as DFB laser with the tunable DBR section
2. Tuning range can cover 12-16 100G channels





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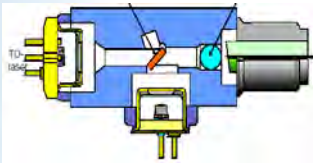
Manufacturing Process

Laser Chip

TO Packaging

BOSA



Module

No	Tasks	Actions
1	Improve the laser yield	With the production volume increasing and the yield improvement, the tunable laser cost may be reduced
2	Reduce the cost of packaging	The traditional WDM TOSA is packaged with the XMD. Since the output power of the Super-PON lasers are relaxed, the inexpensive TO can be used for the application
3	Manufacturing improvement	Improve the manufacturing efficiency
4	Simplify the testing and calibration	Testing and calibration automation

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ONU TOSA Relative Costs

	Uncooled laser (DML)	Cooled laser – single λ	Cooled laser – partially tunable (e.g., 4 λ)	Cooled laser – fully tunable (e.g., 12 λ)
1 Gb/s	1x	5 to 10x	6 to 12x	8 to 15x
2.5 Gb/s	1x	5 to 10x	6 to 12x	8 to 15x
10 Gb/s	4x	8 to 15x	10 to 18x	12 to 22x

- $\lambda \in$ C-band (1530 .. 1565 nm)
- Nominal channel spacing: 100 GHz

	1 Gb/s	2.5 Gb/s	10 Gb/s
Launch power	-1 to 4 dBm	-1 to 4 dBm	4 to 9 dBm

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P2P TOSA Relative Costs

	Uncooled laser (DML)	Cooled laser – single λ	Cooled laser – partially tunable (e.g., 4 λ)	Cooled laser – partially tunable (e.g., 12 λ)	Cooled laser – fully tunable (e.g., C-band)
10 Gb/s	1x	3.5x	4x	5x	12x

- $\lambda \in$ C-band (1530 .. 1565 nm)
- Nominal channel spacing: 100 GHz
- -10 to -5 dBm launch power

Cost Trend

- As of today, PON have been deployed widely and about 70M new ONU terminals are added per year. In the past ten years GPON prices dropped to 1/10 with demand increase and cost reduction efforts
- Now DWDM TOSA cost is ~5x higher than the cost of 10G-PON uncooled TOSA. It is expected that DWDM TOSA cost may reach ~3x of the uncooled TOSA with volumes increasing
- The tunable DWDM TOSA cost (with 12 λ tuning) is expected to be about 50% higher than the cost of the fixed DWDM TOSA

Summary

- The Super-PON architecture is the best solution to expand the subscriber numbers and reach longer distance with low cost per subscriber
- DBR tunable lasers are very promising for the Super-PON architecture
- The inventory and operational cost of tunable WDM-PON modules will be much lower than that of the fixed wavelength modules
- The cost of optical modules may be reduced by lower output power requirements of transmitters in Super-PON
- The cost of tunable WDM-PON modules can be further reduced by higher deployment volumes, yield improvements of key components, and improved production efficiency