Feasibility Study of 4x10G CWDM
- Potential Evolution of Technology -

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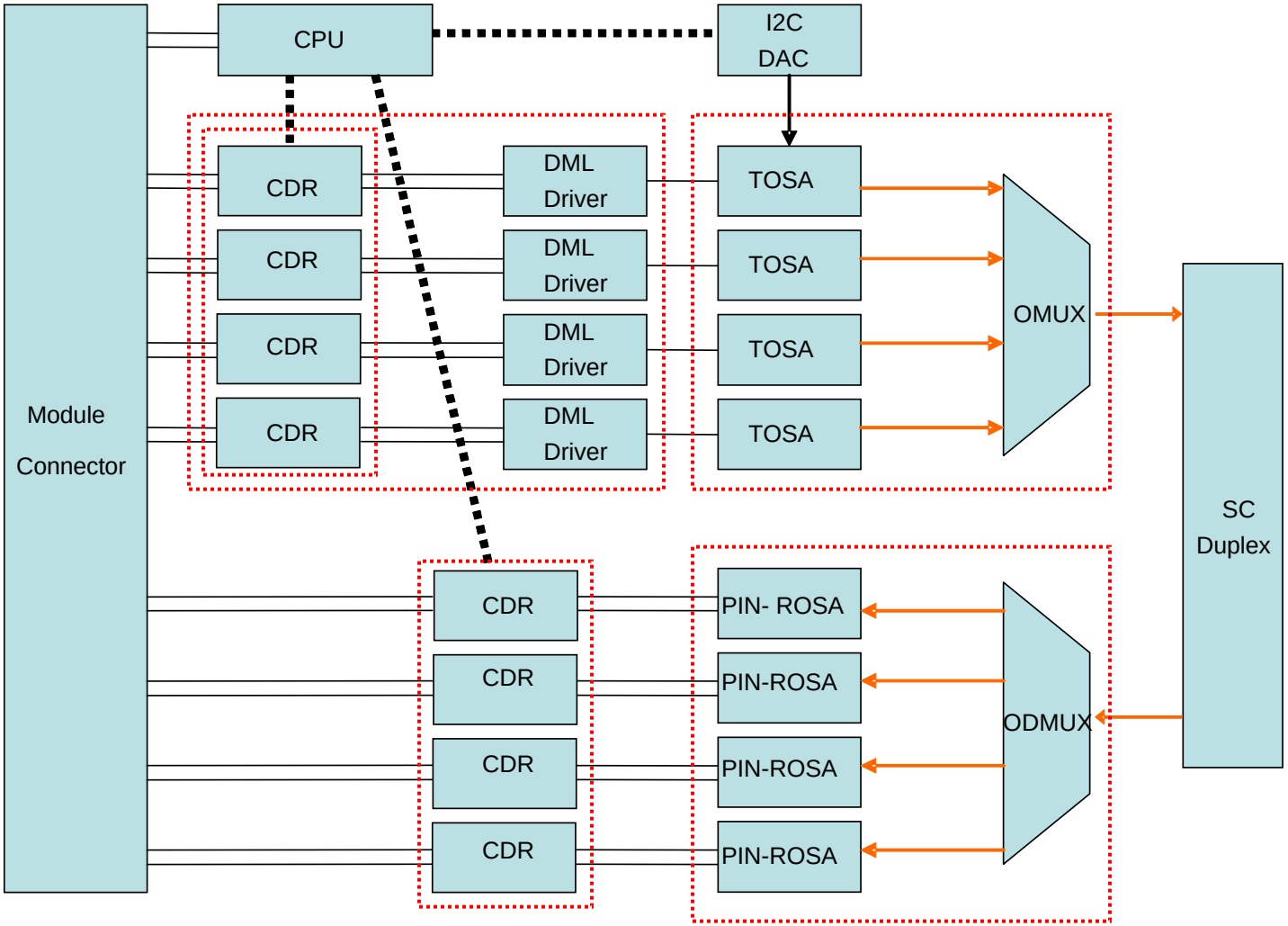
Outline

- Block diagram of 4x10G CWDM
- 1st generation 4x10G CWDM
- 2nd generation 4x10G CWDM
  - Expecting evolution
  - Compact TOSA with OMUX
  - Power reduction strategy
  - Example (10GBASE-LR SFP+)
  - Power consumption table update
  - OSA relative cost estimation at 2010
- Summary

Block Diagram of 4x10G CWDM



1st Generation 4x10G CWDM - High-lights and Low-lights -

High-lights

- Discrete 10G TOSA and ROSA is used with OMUX/DEMUX module
  - TOSA can leverage 10GBASE-LR transceiver quantity
    - 4x10G CWDM wavelength range (1264.5 to 1337.5nm) is within 10GBASE-LR wavelength range (1260 to 1355nm) and CWDM LD for 4x10G can be used for 10GBASE-LR
  - ROSA can leverage 10GBASE-LR/OC192-SR1/IR2 transceiver quantity

    No additional design effort is required for ROSA
  - Fusion splice or pigtail w/ optical connector will be used
- CDR IC can leverage XFP transceiver quantity
- LD driver IC can leverage 10km XFP/SFP+ transceiver quantity
- Manufacturing process can leverage existing system for 10km XFP/SFP+
  - Investment for equipment and tool for manufacturing is minimal
  - Manufacturing process is so matured and easy to reduce inspection time by key component pre-screening or guaranteed performance by design

Low-lights

- Difficult to reduce transceiver size (Up to double size of X2 transceiver)
- Not manufacturing friendly owing to fiber pigtail assembly

2nd Generation 4x10G CWDM - Expecting Evolution -

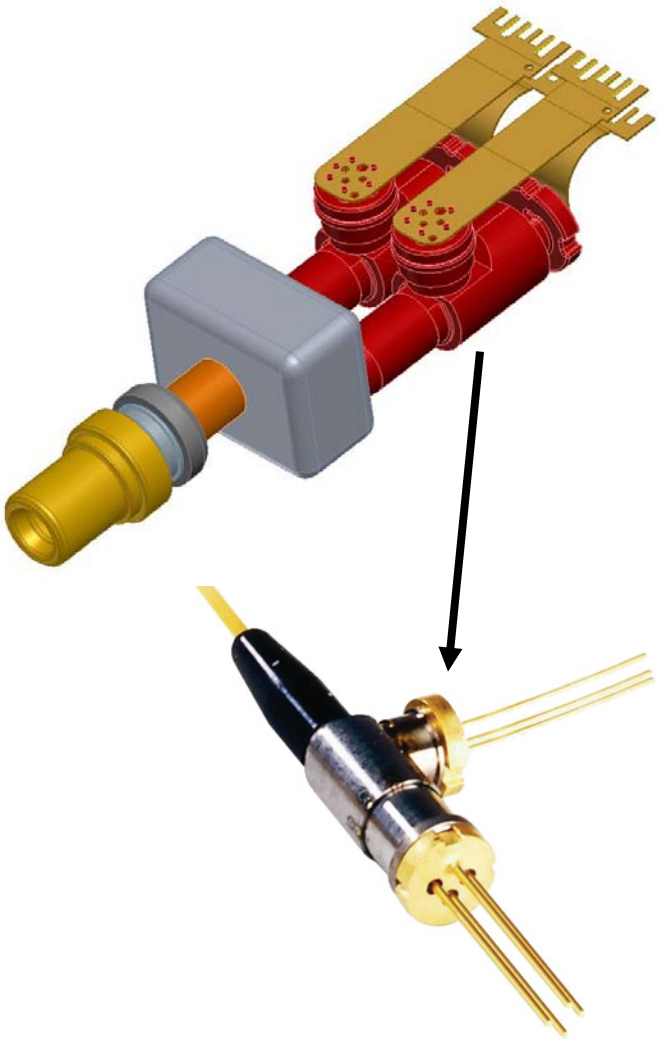
Small Form Factor

- Appropriate level TOSA/OMUX integration is the key
  - Maintain same level transmitter performance with existing 10G transceiver
  - Maintain ease of manufacturing as existing 10G transceiver level
  - Investment for manufacturing and development have to be minimized
- ROSA/ODEMUX integration which is used for 10GBASE-LX4 is applicable to 4x10G CWDM because of low technical risk
- Appropriate level IC integration is required
  - CDR integration to 4ch CDR from 1ch CDR
  - LD driver integration to CDR

Low Power Consumption

- Power reduction of optical transmitter is the key
- Appropriate level IC integration is required to remove circuit redundancy
- Using lower supply voltage as possible combined with high efficiency DC/DC converter

2nd Generation 4x10G CWDM - Compact TOSA with OMUX -



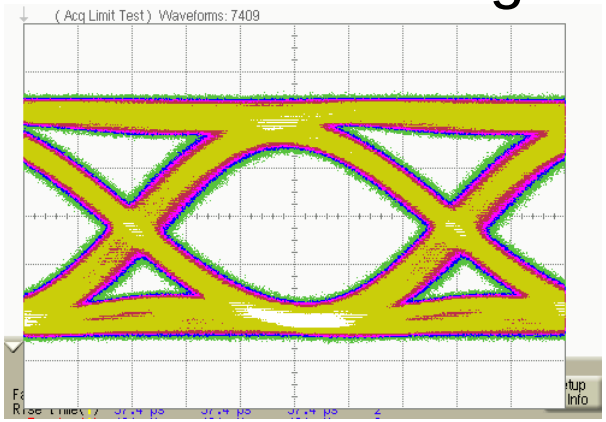
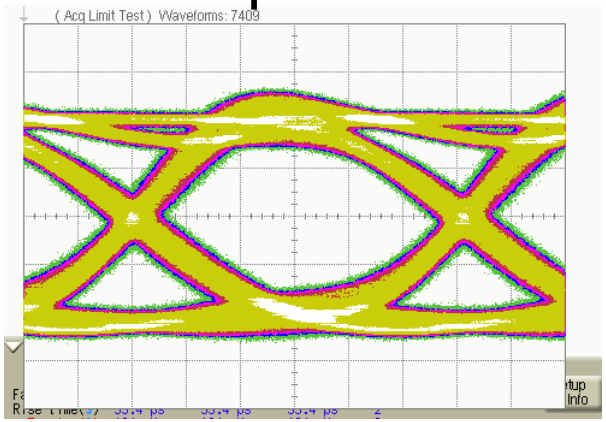
Combine a pair of 2-wavelength OMUX-TOSA with simple OMUX module

- Can fit to SC duplex width transceiver such as X2 transceiver
- Using diplexer style structure for OMUX-TOSA
  - OMUX part has low cost design which is same concept as existing diplexer
  - Can use same assembly technology and equipment for diplexer/triplexer whose market size is larger than 10Mpcs/year
  - Doesn't require difficult transceiver PCB layout or difficult assembly without any transmitter performance degradation
- LD CAN part can leverage 10GBASE-LR transceiver quantity
- Complex optical alignment or tighter tolerance mechanical part is not required

2nd Generation 4x10G CWDM - Power Reduction Strategy -

- Optical transmitter power reduction
  - Reduce transmitter power reduction by circuit design optimization
  - Reduce LD operating current by chip design optimization (Getting enough bandwidth at low operating current and high temperature)
- Minimize circuit redundancy by integration
  - LD driver integration to CDR can reduce CDR output buffer and LD driver input buffer power consumption
- Using lower supply voltage as possible combined with high efficiency DC/DC converter

2nd Generation 4x10G CWDM - Example (10GBASE-LR SFP+) -

	Incumbent Design	After Optimization
Optical waveform		
Optical input sensitivity	**-17.1dBm @25degC, Vcc=3.3V**	**-17.7dBm @25degC, Vcc=3.3V**
Power consumption **(0.25W saving)**	**1.0W** (compliant with SFP+ MSA power level 1) **@70degC, Vcc=3.3V+10%**	**0.75W @70degC, Vcc=3.3V+10%**

- 25% power reduction is proved by actual SFP+
- More reduction of 4x10G CWDM is doable by applying power reduction strategy

2nd Generation 4x10G CWDM
- Power Consumption Table Update -

Item	2008 (4xSFP+ and 4xCDR)	2008	2010
DML TOSA w/OMUX	3.0W [1] (4xSFP+)		
4 x DML Driver		1.7W	1.5W
4 x PIN-TIA ROSA w/ODEMUX		0.64W	0.5W
Other		0.2W	0.1W [2]
4 x CDR	1.8W	1.8W	1.0W
Total	4.8W	4.34W	3.1W

1) Including 100mW/ch power consumption for limiting amplifier which can be integrated in CDR, and including 65mW/ch power consumption for other circuit such as CPU which can be reduced by sharing CPU.
2) Assume to use low power CPU

2nd Generation 4x10G CWDM
- OSA Relative Cost Estimation at 2010 -

Item	10GBASE-LR	10GBASE-LX4	40GBASE-LR4
DML TOSA w/OMUX	2	6-7.5*	12-15*
4 x PIN-TIA ROSA w/ODEMUX	1	2-2.5*	4-5*
OSA total	3	8-10* (2.7xLR-3.3xLR)	16-20* (5.3xLR-6.7xLR)

*) Relative cost estimation depends on vertical integration effect.

Item	10GBASE-LR	40GBASE-LR (traverso_02_0708)	40GBASE-LR4	
			traverso_02_0708	tsumura_01_0908
OSA total	1	5.9	8.4	5.3-6.7

No significant OSA cost is assumed between 40GBASE-LR4 and 40GBASE-LR

Summary

- 1st generation 4x10G CWDM is ready with maximum power consumption of 4.8W and double size of X2 transceiver.
- 2nd generation 4x10G CWDM requires new 4x10G CWDM TOSA w/OMUX and ROSA w/ODEMUX to realize X2 transceiver size. However, its investment will not be so large by leveraging diplexer technology for TOSA and LX4 technology for ROSA. Also, maximum power consumption of 3.1W is feasible in 2010. It may allow to use 40GE SMF 10km transceiver for high port density application.