Symmetric 10GEPON – Jitter Budget

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Outline

- An Introduction to Jitter
- Jitter Budget – DS
- Jitter Budget – US
- Conclusions

Why is Jitter Important?

- Jitter causes bit errors
- Jitter Budget → equivalent to BER
- Identify Jitter components → Increase performance

Sources of Jitter

- Crystal
- PLL
- Transmitter
  - Laser
  - Modulator
- Fiber
  - Chromatic Dispersion
- Detector
  - Thermal
  - Shot
- CDR
  - ISI
  - Thermal
  - Sampling Error

Types of Jitter 1/2

- Correlated
  - Deterministic Jitter (DJ)
  - Data Dependent Jitter (DDJ)
  - Inter-symbol Interference (ISI)
  - Duty Cycle Distortion (DCD)

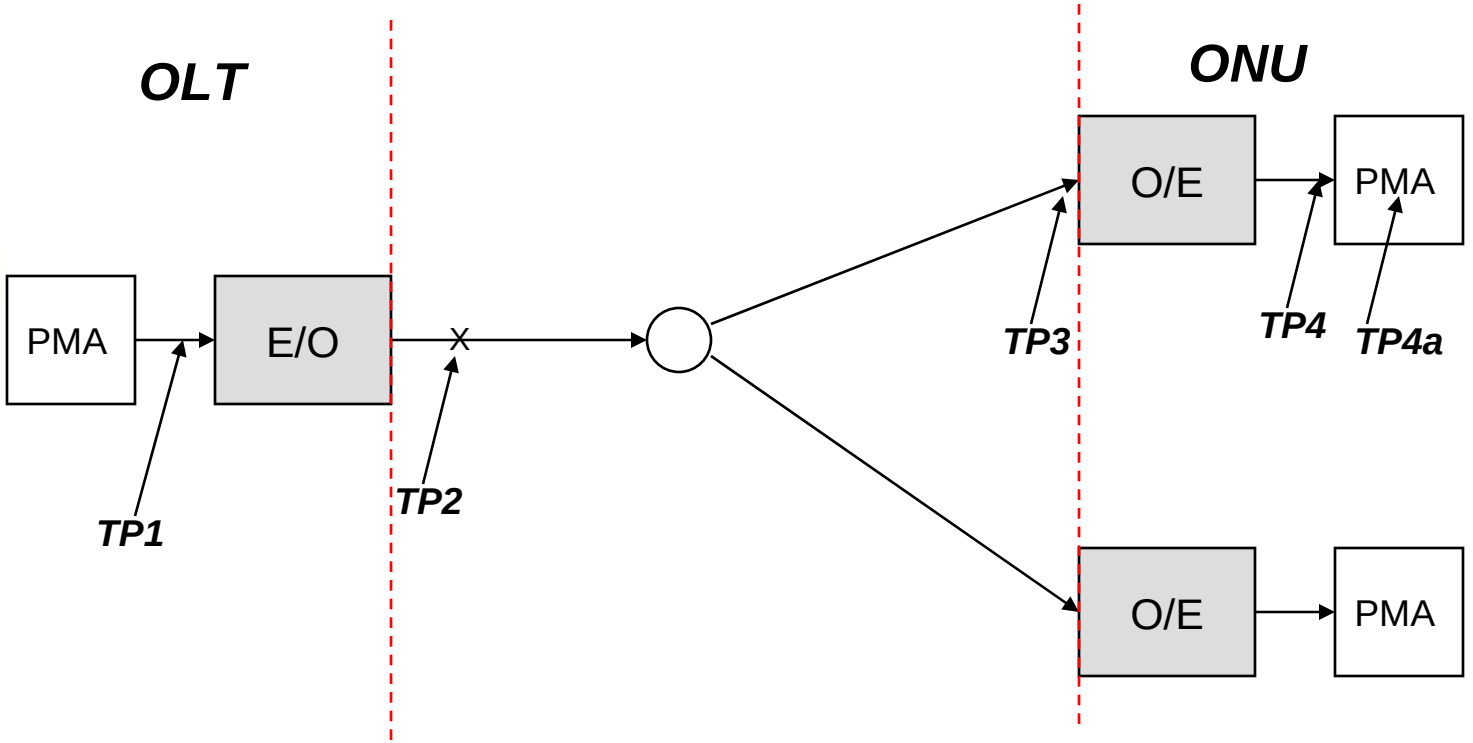
- Uncorrelated
  - Random Jitter (RJ)
  - Deterministic Jitter (DJ)

Types of Jitter 2/2

- Deterministic Jitter (DJ)
  - Jitter with non stochastic characteristics – Could be varying in time
  - Four kinds of Deterministic Jitter are identified
    - DCD
    - ISI
    - SJ
    - Cross Talk
- Random Jitter
  - Stochastic in nature with a probability density function (usually modeled as Gaussian)
  - accumulates from thermal noise and shot noise sources.
  - Characterized by RMS value
  - Unbounded (additive by Sum of Square)
  - The number of Sigma taken for total value is depending on BER point
  - Rj_ptp=14.1* Rj_rms @ 1e-12
  - Rj_ptp=6.2* Rj_rms @ 1e-3

The Model
DS

10GEPON DS – Jitter Test Points



DS – Test Points Assumptions

- TP1
  - Jitter from the OLT PHY
- TP2
  - Tx Optical ISI
  - E-to-O Jitter (EML Modulator)
- TP3
  - Fiber Optic Cable “Jitter” (ISI)
  - Chromatic Dispersion
- TP4
  - O-to-E Jitter
  - Rx Optical ISI

Jitter Budget Assumptions – DS

- TX RJ (EML Laser) – 0.15UI
- Jitter from E-to-O and O-to-E is split 50/50 between DJ and RJ
- Allow for up to 0.1UI of DCD (45/55)
- Chromatic Dispersion leads to ISI
  - Chromatic Dispersion is the variation in the speed of propagation of a light wave signal with wavelength
  - It leads to spreading of the light pulses and eventually to ISI with increased bit error rate (BER).
- RX RJ – 0.15UI
- Margin – 0.1UI

TP4 to TP4a

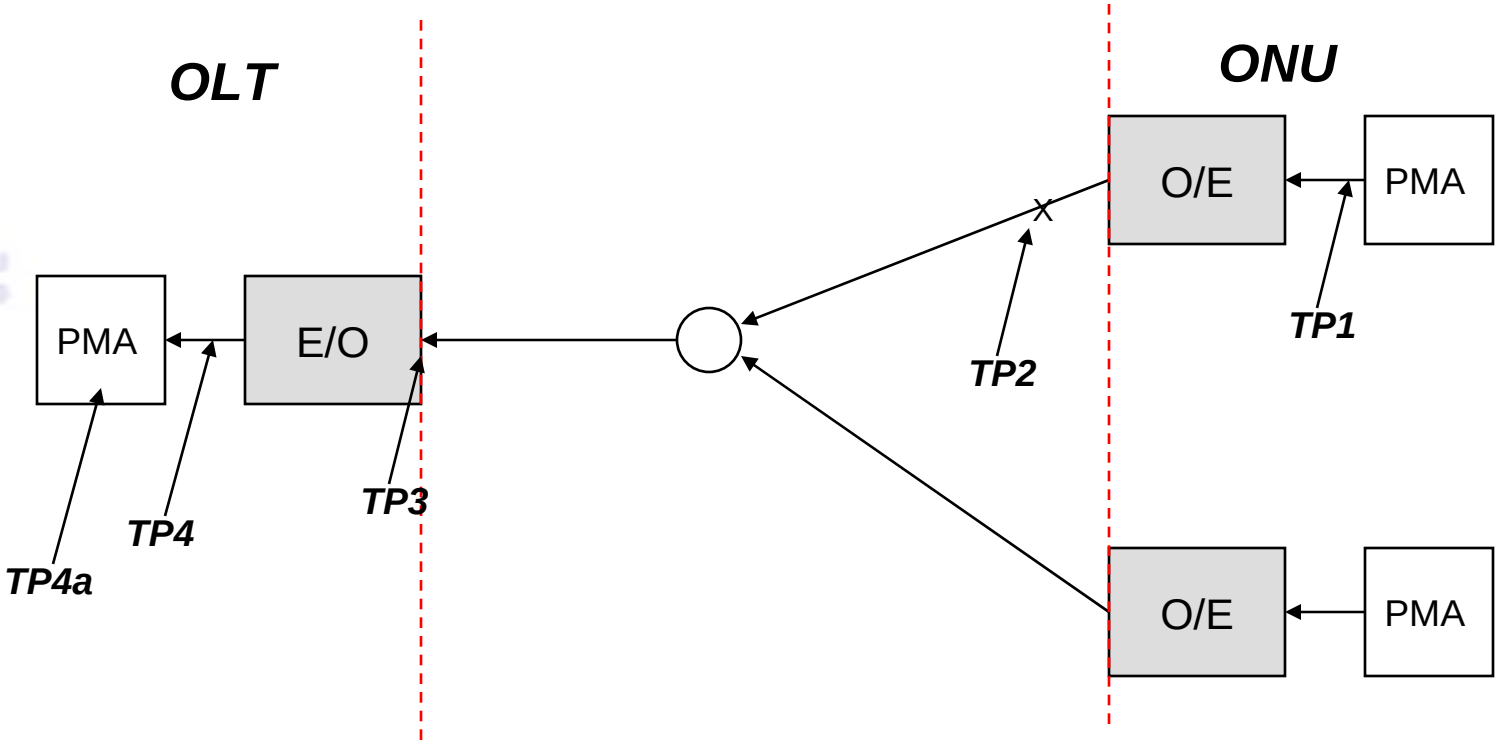
- In addition to TP4 budget, we have to add Margin and additional Jitter to clock data recovery “on Chip” – Define TP4a
- The additional Jitter is “Uncorrelated Jitter” around 0.35UI
- The jitter budget @ TP4a should be below 1UI
- Current Total Jitter at TP4a is 1.1UI
- Equalizer could reduce the Jitter by 0.2UI to 0.9UI and meet the budget

10GEPON DS

	Uncorrelated Jitter		Correlated Jitter		Total		Test Points
Units	UIpp	ps	UIpp	ps	UIpp	ps	
Tx	0.18	17.5	0.00	0.0	**0.18**	**17.5**	TP1
TX Optical output	0.23	22.7	0.12	11.2	**0.35**	**33.9**	TP2
Fiber	0.05	4.8	0.15	14.5	**0.20**	**19.4**	
RX Optical input	0.400	38.8	0.25	24.2	**0.56**	**54.3**	TP3
Rx	0.48	46.5	0.35	33.9	**0.83**	**80.5**	TP4
Befor Equalizer					1.08	**104.7**	TP4a
After Equalizer					0.88	**85.3**	TP4a_eq

The Model
US

10GEPON US – Jitter Test Points



US – Test Points Assumptions

- TP1
  - Jitter from the ONU PHY
  - Loop Timing Jitter
- TP2
  - Tx Optical ISI
  - E-to-O Jitter
- TP3
  - Fiber Optic Cable “Jitter” (DCD)
- TP4
  - O-to-E Jitter
  - Rx Optical ISI

Jitter Budget Assumptions – US

- TX RJ (DFB Laser) – 0.05UI
- Jitter from E-to-O and O-to-E is split 50/50 between DJ and RJ
- Allow for up to 0.1UI of DCD (45/55)
- Chromatic Dispersion at 1270nm is practically 0.
- RX RJ – 0.15UI
- Margin – 0.1UI

TP4 to TP4a

- In addition to TP4 budget, we have to add Margin and additional Jitter to clock data recovery “on Chip” – Define TP4a
- The additional Jitter is “Uncorrelated Jitter” around 0.25UI
- The jitter budget @ TP4a should be below 1UI
- Current Total Jitter at TP4a is 0.99UI
- Equalizer could reduce the Jitter by 0.09UI to 0.90UI and meet the budget

10GEPON US

	Uncorrelated Jitter		Correlated Jitter		Total		Test Points
Units	UIpp	ps	UIpp	ps	UIpp	ps	
Tx (input J)	0.300	29.1	0.00	0.0	**0.30**	**29.1**	TP1
TX Optical output	0.400	38.8	0.06	5.8	**0.46**	**44.6**	TP2
Fiber	0.050	4.8			**0.05**	**4.8**	
RX Optical Input	0.312	30.3	0.208	20.2	**0.52**	**50.4**	TP3
At Rx Inputs	**0.470**	**45.5**	**0.300**	**29.1**	**0.77**	**74.7**	TP4
Befor Equalizer					**0.99**	**96.0**	TP4a
After Equalizer					**0.90**	**87.3**	TP4a_eq

Improvements at TP1 (DS)

- Pre-Emphasis can reduce 0.08UI from ISI at TP1.

Conclusions

- Equalizer is mandatory, otherwise the link will not exist
- Need to address Loop Timing in Asymmetric Mode (Jitter Transfer)
- We propose the following Jitter Budget:

	DS		US	
	[UI]	[PS]	[UI]	[PS]
TP1	0.18	17.0	0.30	29.1
TP2	0.35	33.5	0.46	44.4
TP3	0.56	54.3	0.52	50.7
TP4	0.83	80.2	0.77	74.9
TP4a	1.08	104.3	0.99	95.7
TP4a_eq	0.88	92.2	0.90	87.3

Note:
TP4a – Pre-Equalizer “test point”
TP4a_eq – Post-Equalizer “test point”

Back Up