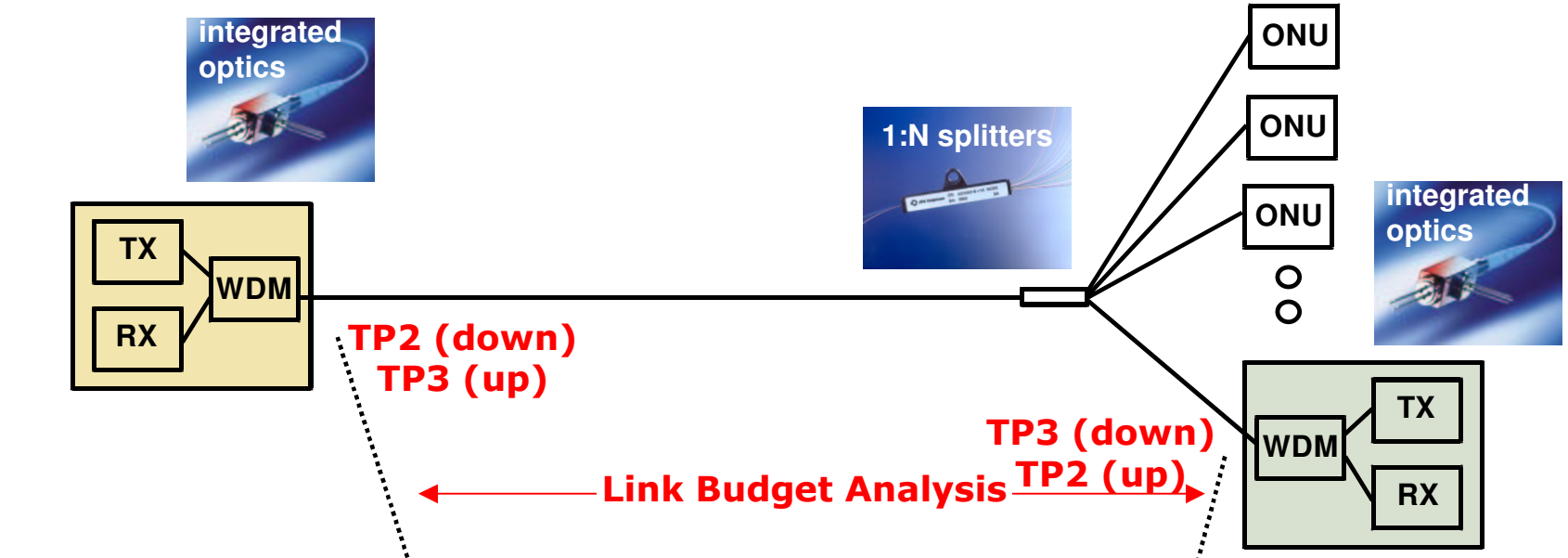
Feasible Parameters for EPON Transceivers

Bartur, Meir - Zonu
Bhatt, Vipul - Finisar
Blauvelt, Hank – cQuint
Diab, Wael – Cisco
Eaton, George – Intel
Haile-Mariam, Atikem - Ignis
Iannelli, John – Agere
Ivry, Raanan – Broadlight
Koziuk, Glen - Vitesse
Jewell, Jack – Picolight
Khermosh, Lior - Passave
Kuo, JC – Alloptic
Murphy, Tom – Infineon
Rooks, Sterling - Stratos
Won, Shinhee - Samsung

Review: An example of EPON Topology



Scope: Baseline Parameters for EPON Transceivers

- The purpose of this presentation is to identify a baseline set of parameters that is technically and economically feasible for PON transceivers
- The analysis is for a 2-wavelength window system (1550/1310)
  - May substitute 1490 for 1550
- Cost comparison/impact is relative to standard components used in Gigabit Ethernet which are operating in the same environment

Parameter Summary

Parameter	Proposed Value	Cost Impact	Remarks
OLT TX/RX isolation	-26dB	not significant	System vs. tranceiver specification
ONU TX/RX isolation	-15dB	not significant	System vs. tranceiver specification
Burst OFF Power (upstream)	-45dBm	not significant	10 dB < APD sensitivity @OLT receiver
TX ON time (upstream)	25nsec	not significant	
TX OFF time (upstream)	25nsec	not significant	
RX AGC time	50nsec	not significant	split into optics and clock recovery (system)
* Figures intended as "ball park" worst case achievable parameters that indicate technical feasability			

Detailed Information

Transceiver OLT TX/RX isolation

- Definition: *This is a system parameter that is measured at the transceiver/fiber interface (TP2/TP3).*
- Requirement: To protect against noise and cross-talk from the transmitted signal coming back into the receiver.
- Calculation:
  - Maximum transmit power at head-end: +4 dBm
  - Return loss (assuming a worst case 1:2 split with an un-terminated branch): -20dB
  - APD sensitivity with 10 dB margin: -42 dB
  - Isolation = -42 – (-20 + 4) = -26
- Proposed Value: -26dB

Transceiver ONU TX/RX isolation

- Definition: *This is a system parameter that is measured at the transceiver/fiber interface (TP2/TP3).*
- Requirement: To protect against noise and cross-talk from the transmitted signal coming back into the receiver.
- Calculation:
  - Maximum transmit power at CPE-end: +1.5 dBm
  - Fiber plant return loss –26 dB. [OLT ORL –20 dB and one 1:2 splitter worst case. Combined –23 dB ORL]
  - Sensitivity with 10 dB margin: -36 dB
  - Isolation = -36 – (-23 + 1.5) = -14.5
- Proposed Value: -15dB

OFF (Leakage) Power of the Burst mode transmitter (ONU)

- Definition: *maximum output power measured at the output of the ONU transceiver when the device is powered but not transmitting (I.e. during a transmission slot of another ONU)*
- Requirement: To ensure that the total output of all the "off" transmitters does not overwhelm the receiver
- Calculation:
  - Sensitivity of an aggressive APD = -32 dBm
  - -3 dB for overshoot
  - -10 dB margin (lower than the sensitivity of an APD)
  - => -32 –10 –3 = -45 dBm
- Proposed Value: -45dBm

TX Turn_ON time (ONU)

- Definition: *maximum time for the transmitter of an ONU to go from the off state to a stable on state when the TX_ON signal is asserted. (I.e. during the startup for transmission in the ONU's slot).*
- Requirement: When there is a transition between 2 ONUs the ONU that will transmit will need to switch on its transmitter.
- Calculation: broken up into 3 parts
  - laser switch on (optics)
  - laser stabilization (optics)
  - control loop stabilization (drive electronics)
- Proposed Value: 25 nsec.

TX Turn_OFF time (ONU)

- Definition: *maximum time for the transmitter of an ONU to go from a stable on state (maximum output power) to the off state when the TX_ON signal is de-asserted. (I.e. during the end of a transmission in the ONU's slot).*
- Requirement: When there is a transition between 2 ONUs the ONU that will stop transmitting will need to switch off its transmitter.
- Calculation: Assumed a very conservative number that is symmetric to TX_ON.
- Proposed Value: 25 nsec.

RX stabilization time: AGC Timing

- Broken up into 2 parts: Control loop timing & Clock recovery timing
- Control Loop timing is part of the system specification and will not be defined here
- RX AGC Timing Definition: *maximum time for the receiver of an OLT to adjust to a new ONU. (I.e. during the start of a a new ONU transmission).*
- Requirement: When there is a transition between 2 ONUs the OLT receiver will need to adjust its power level according to the ONU's transmission characteristics.
- Calculation:
- Proposed Value: 50 nsec.

RX stabilization time: Dynamic Range

- Dynamic Range Definition: *maximum delta in transmit power between 2 consecutive ONUs, measured at the OLT transceiver (TP2).*
- Requirement: When there is a transition between 2 ONUs the OLT receiver will need to adjust its power level according to the ONU's transmission characteristics.
- Proposed Value: >= 15 dB.

RX stabilization time: Clock Recovery

- Outside the PON transceiver.
  - Transceiver interface is the digital electrical serial stream
- Not specified in this presentation
- Clock Recovery Definition: *maximum time for the PMD of an OLT to acquire synchronization from a new ONU. (I.e. during the start of a a new ONU transmission).*
- There is a choice depending on the system requirements
  - Phase locking: assumes a synchronous clock in the EPON system
  - Frequency locking: CDR
- For reference a ball park figure is stated*
  - Phase locking: 10 bit times = 8 nsec
  - Frequency locking: 400 bit times = 320 nsec

  * numbers do not assume any FEC

Summary of ONU transition overhead

- Example: going from ONU1 transmitting to ONU2 transmitting
- Worst case time includes
  - ONU1 tx_OFF: 25 nsec
  - ONU2 tx_ON : 25 nsec (we may be able to overlap this with the above)
  - OLT_rx_agc : 50 nsec
  - OLT_rx_sync : 8 nsec or 320 nsec depending on clock recovery method employed
- Total Worst case time for a phase locking implementation: 108 nsec
- Total Worst case time for a frequency locking implementation: 420 nsec
- Guard band - System issues may contribute to extra guardband

Conclusion & Summary

EPON Transceivers parameters listed are technically and economically feasible using 1310/1550 windows for VCSEL, DFB, FP lasers.

Assumptions

FP = 2.8 nm, k=0.5, 1280 to 1350nm
DFB = 0.2 nm, k = 0.0, 1260 to 1360nm
VCSEL = 0.2nm, k = 0.0, 1260 to 1360nm
Fiber Attenuation 0.5 dB/km @ 1310nm
Fiber Attenuation 0.3 dB/km @ 1550nm
1:16 Splitter 14.3 dB max
1:32 Splitter 17 dB max
Connectors 2.0 dB
Temperature –40 to +85C
Integrated Transceiver Isolation 35 dB
Rise/fall time = 260ps; DCD/DJ = 80ps
RIN = -120dB*$Hz^{-1/2}$
"Fiber-end-to-fiber-end" link specification
"TP2-to-TP3"
* Need more analysis on the behavior of the fiber plant