PON PMD Timing

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Outline

- PON timing overview
- General design considerations
- Current ITU-T PMD situation
- Gigabit PON PMD in practice
- Strategy
- Conclusion

PON Timing Overview

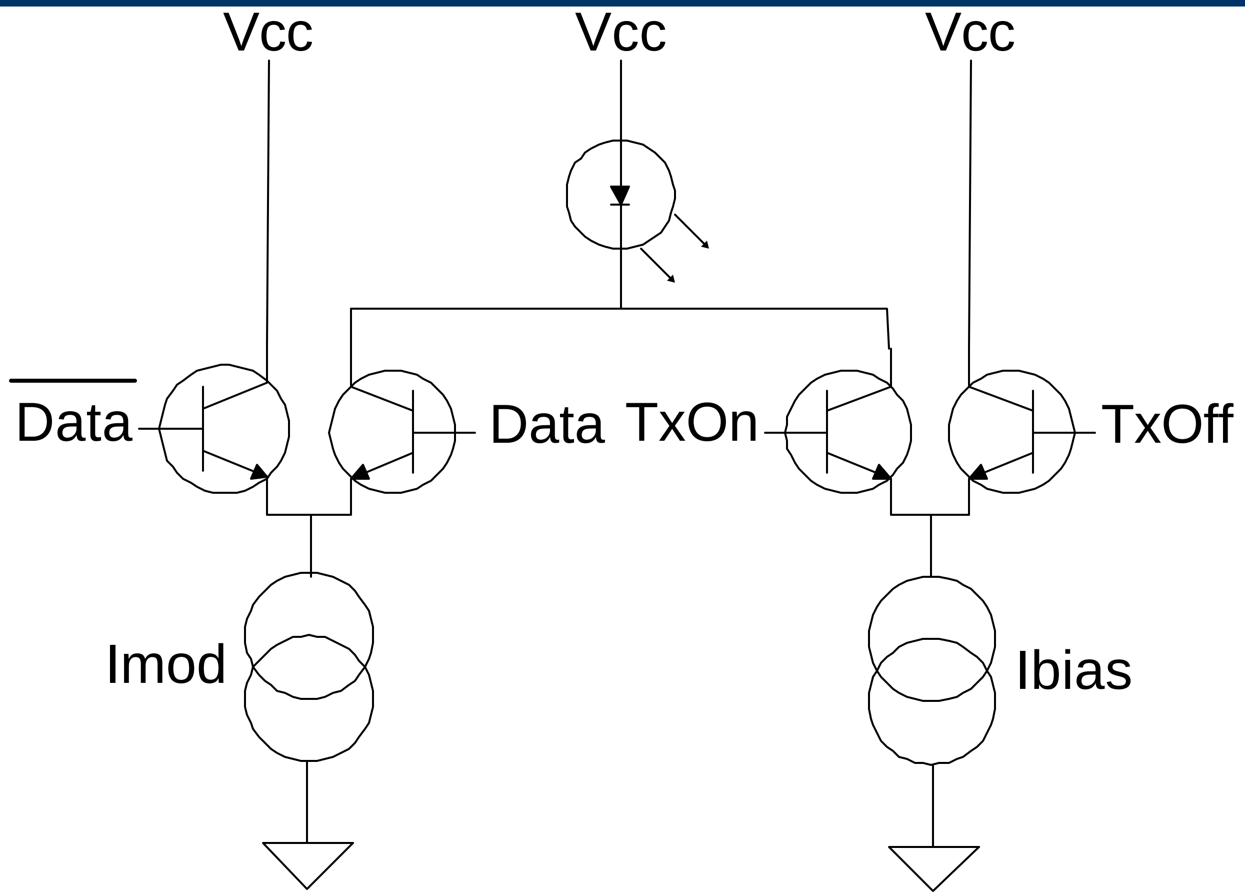
- PON timing can be described by 6 attributes
  - Tx On time, Ton
  - Tx Off time, Toff
  - Rx Dynamic Sensitivity Recovery time, Tdsr
  - Rx Level Recovery time, Tlr
  - Rx Clock Recovery time, Tcr
  - Rx Delimiter time, Tdl
- Note that in 802.3ah, Tcr is in domain of PMA, and Tdl is in domain of PCS and MAC

Our focus here is PMD

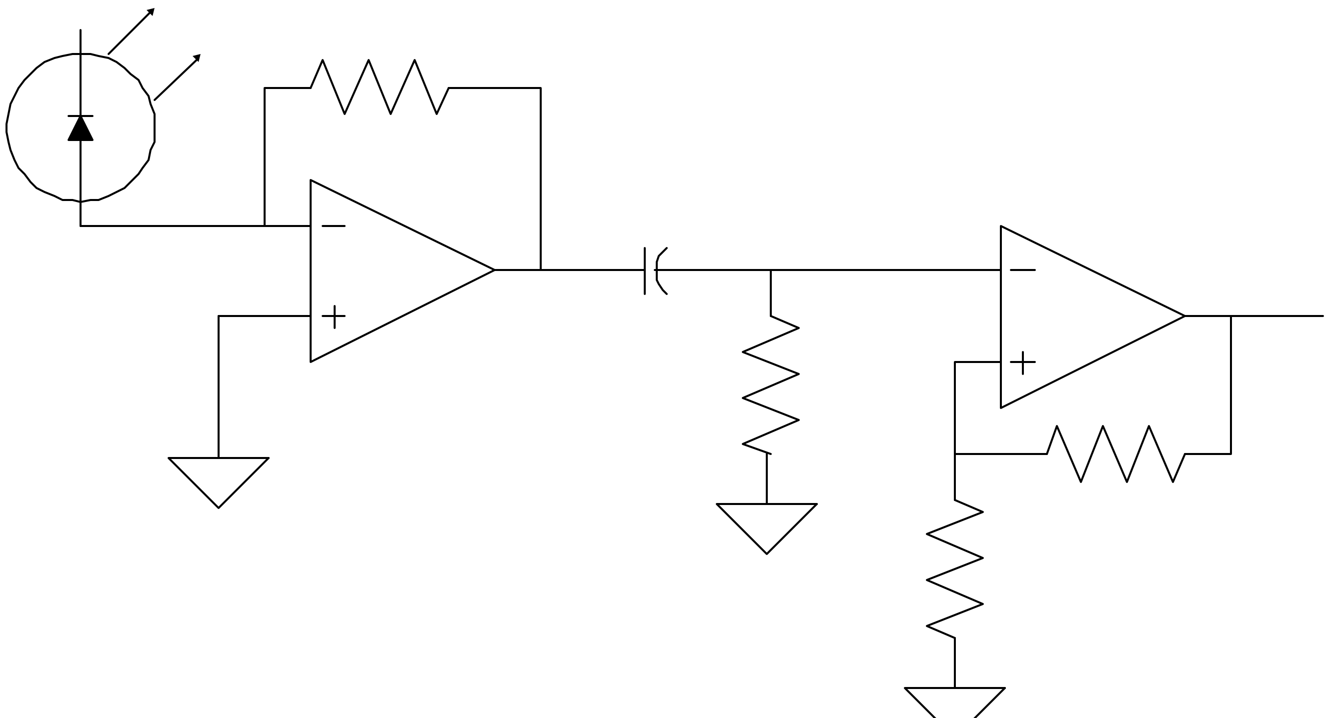
- Transmitter times
- Ton limited by driver circuitry stabilization of laser bias
- Toff limited by speed of ‘switching element’
- Laser is never limiting element

- Receiver times
- Tdsr limited by
  - Circuit slewing rates
  - PIN diffusion tails
- Tlr limited by
  - Accurate measurement of threshold level
  - Speed of track and hold circuits (if used)

General Design Considerations, Transmitter



General Design Considerations, Receiver



Current status of ITU-T

- G.GPON.pmd is the outcome of extensive deliberations of the world's PON experts
  - It provides a comprehensive set of specifications for PON optics at many rates, including symmetric Gigabit per second
- G.GPON.pmd has been submitted as a white contribution to SG-15 plenary
  - It will be consented on Jan 31, 2003

What G.GPON.pmd says

- The document specifies normatively:
  - Ton = 16 bits (12.9 ns)
  - Toff = 16 bits (12.9 ns)
  - Total burst overhead time = 96 bits (77.2 ns)
- The document specifies informatively:
  - Guard Time = 32 bits
  - Preamble Time = 44 bits
  - Delimiter Time = 20 bits

How to map timing parameters

- The guard time includes
  - Laser On and Off times
  - Timing inaccuracies of protocol (small for GPON)
  - Dynamic sensitivity recovery time (Tdsr)
  - All of these can overlap to some degree
- The preamble time includes
  - Level recovery time (Tlr)
  - Clock recovery time (modest in GPON)

"Equivalent" values for EPON

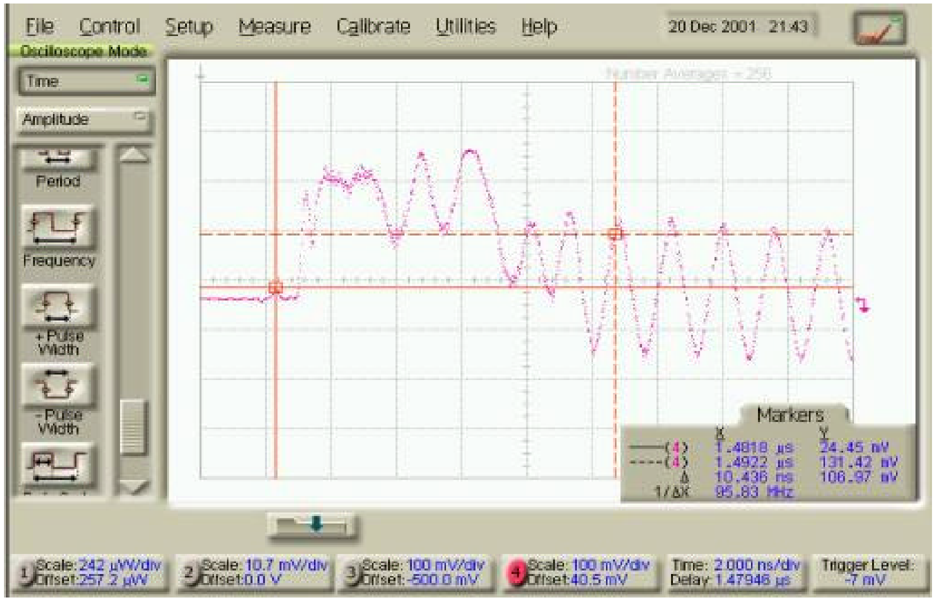
- Ton and Toff are close to 2 symbol times
  - Ton = 16 ns
  - Toff = 16 ns
- If we subtract out the time for delimiter (20 bits) and clock recovery (12 bits) in GPON, we obtain 64 bits for PMD related functions
  - Tdsr+Tlr = 50 ns

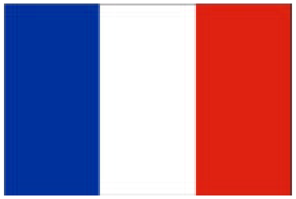
PON Timing in Practice

- The following slides give illustrative examples of Gigabit rate PON optics that achieve ITU-T timing

Example: FlexLight-Network

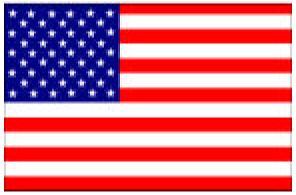
- Burst control at the ONT Tx
  - No cost penalty associated with Ton/Toff times of 16 ns
- Data and clock recovery at OLT Rx
  - Less than 12 ns (10 bits @ 1.244 GHz) lock time





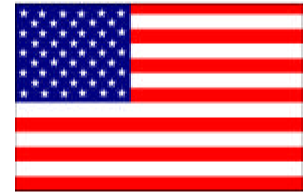
Example: Alcatel

- "Alcatel, together with partners, is currently developing GPON modules for meeting the ITU-T spec at 1.244 Gbit/s, including the timing parameters."



Example: Maxim Semiconductor

- Burst Mode Laser drivers @ 1.2 & 2.5 G
  - Ton and Toff < 2 ns with a PON design
  - Ton and Toff ~10 ns with existing P2P design and auxiliary S&H circuits
- Burst Mode Receiver @ 1.2 & 2.5 G
  - Tdsr = 6.4 ns, 8 bits at 1.2G
    - Requires arming signal given before burst starts

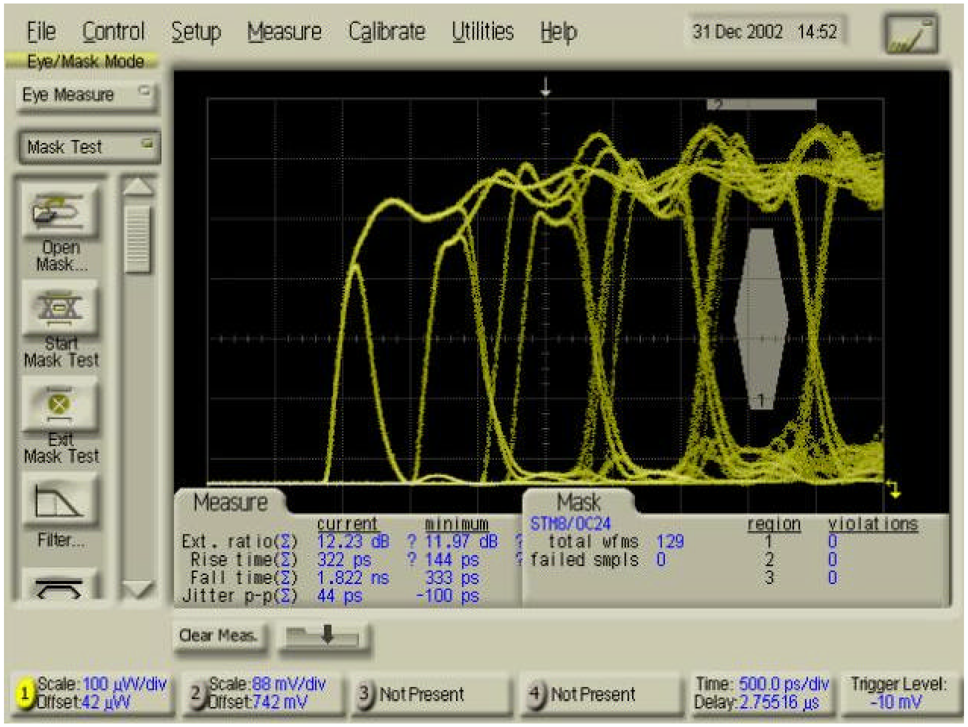


ZONU

- PON ONU transceivers at 0.155, 0.622, and 1.25 G
  - Ton and Toff < 3 ns, regardless of speed

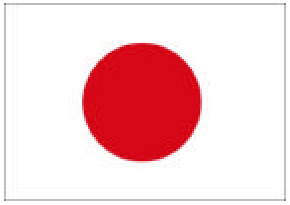
Example: BroadLight

- 1.25 Gb/s ONT Transmitter implementation
  - Ton/Toff times of 4 bits



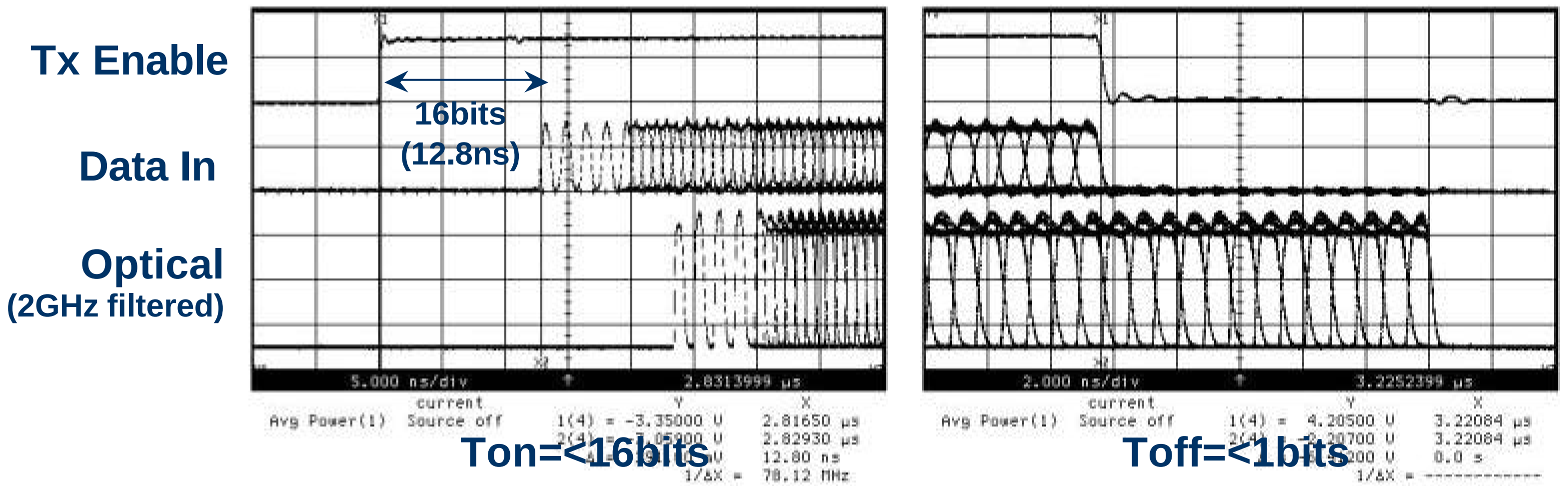
Vendor "X"

- PON ONU transceivers
  - Ton =10~14 ns
  - Toff = 3~5 ns
- Work is still ongoing to improve these values



Example: NEC

- Laser turn-on/turn-off time at ONU Tx
  - Already developed with Ton=<16bits and Toff=<1bits
  - No training procedure is required
- Data recovery time at OLT Rx
  - Targeting Tdsr+Tlr =< 40 ns with reset signal
  - Circuit design is finished (LSI chip is under fabrication)



EPON PMD Strategy

- The current PMD timing ‘debate’ goes back to March 2002
- The two sides (‘tight’ and ‘loose’) have approached the problem from completely different directions

The ‘Tight’ approach

- Determine what are the best times achievable while still being cost effective
- Maintain maximal compatibility between all relevant standards
- Drive towards a single market for PON components to boost volume
- This approach leads one to the ITU values

The ‘Loose’ approach

- Determine what are the worst times permitted by efficiency considerations
- This approach leads one to long values for the PMD times

What the numbers really mean

- Really, the timing numbers presented by both camps are limits, not equalities
- Tight limits: Timing can’t get shorter than X, otherwise component cost goes up
- Loose limits: Timing can’t get longer than Y, otherwise efficiency goes down
- The correct choice lies between

Benefits of ITU concordance

- Optics vendors will have a common set of specifications to use
  - The decision to build PON parts will be easier
  - More optics companies will participate
- There will be a single pool of PMDs and component parts for all PON systems
  - Volume effects will be larger and faster
  - Market uncertainties will be reduced

Think about it

- The Copper track has chosen to defer action pending the line-code decision of T1E1
  - The T1E1 decision hasn't even been made yet
  - Doing so has delayed 802.3ah's schedule in a big way
  - Even then, the benefits of concordance outweigh the costs and risks of doing so
- The Optics track must now make the same choice
  - In contrast, the ITU-T parameters are ready now
  - We can obtain all the benefits at no cost

A Compromise

- A compromise exists (option C), where
  - ONT timing follows the ITU-T values (16 ns for both)
  - OLT timing is ‘negotiable’
- This is favorable because
  - the laser on/off spec is available from several vendors today (technically feasible)
  - no ONU parameter negotiation during discovery
  - it avoids multiple "flavors" of ONTs (important)
  - OLT does not need to keep an ONT parameter table
  - it matches ITU-T specs at the ONT

Compromise (cont.)

- Common ONT gives us 95% of the benefit
  - The ONT is always much more numerous than the OLT, and is cost sensitive
- A flexible OLT avoids 95% of the trouble
  - OLT timing is the harder physics problem
  - Architectural restrictions tend to limit implementation options in the EPON setting

Conclusions

- Option C is optimal choice
  - Broad Market Potential – ✓
  - Compatibility – ✓
  - Distinct Identity – ✓
  - Technical Feasibility – ✓
  - Economic Feasibility – ✓