

Potential ILT Improvement for 200G MMF PMDs

Ali Ghiasi - Ghiasi Quantum/Marvell

IEEE 802.3ds Task Force
Vancouver

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Overview

- ❑ End user's feedback
- ❑ Why Optical Link Training Challenging
- ❑ Key benefit of ILT
- ❑ Enabling ILT for 200G MMF
 - Other possible ILT capabilities
- ❑ Summary.

End Users Feedback on OLT

❑ Traditional DC/Enterprise

- With 11 IMDD PMDs with 5 based on FECo and 6 based on FECi OAN can facilitate deployment and configuration
- Dual mode module can be configured based on remote module capability
- OAN enables zero-touch in fronthaul networks [parkholm_3dj_02_2311](#)

❑ Hyperscale feedback

- Reliable link up in timely manner with OLT and RTS
 - Based on past experience reliable optical link may take much longer than 802.3ck AN+LT link up timers (Make it clear)
 - Expecting reliable optical link up at 200G will be more challenging
- OMA control with LT is most interesting (limited benefits with VCSELs)
 - Mitigate overload
 - Mitigate compression
 - Energy efficiency

❑ OIF EEI (Energy Efficient Interfaces) project has interest in collaborating and potentially leveraging OLT

- See liaison received from OIF [OIF_liaison_IEEE_EEI_Project_21Jan24_Redacted](#).

Why Optical Link Up Challenging

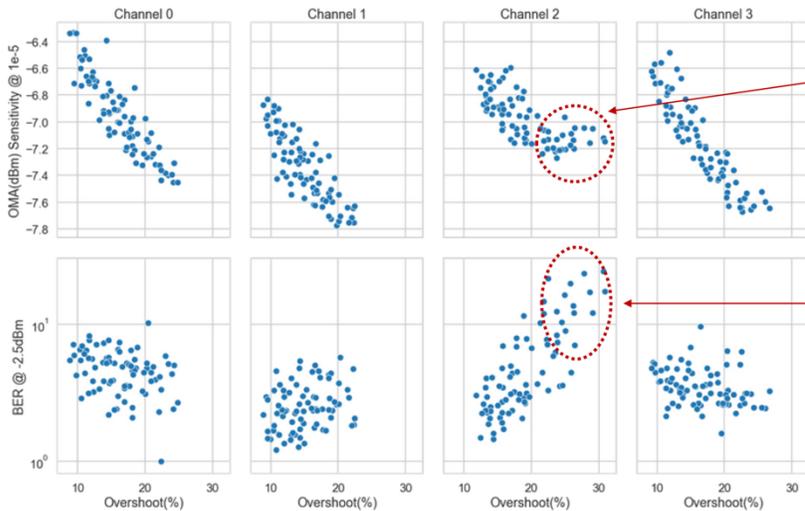
- ❑ **Today's optical SerDes must calibrate and adapt to blind data without even knowing if there is good data**
- ❑ **Link training facilitates multi-segment coordinated bring up resulting in more reliable and timelier link up than just relying on blind link up**
- ❑ **Before any link up and timing recovery**
 - 1st the SAR(Successive Approximation Register) ADCs must be calibrated
 - Offset calibration between all 16/32/64 sub-SAR ADCs
 - Gain calibration between all 16/32/64 sub-SAR ADCs
 - Timing skew calibration between all 16/32/64 sub-SAR ADCs
 - AGC adjust input signal to fully utilize ADC resolution
 - CDR loop, Mueller-Muller or other type of clock recovery
 - DSP equalizer and adaptation
- ❑ **Today's optical DSP SerDes operating with blind start up may require several reset by the module uC while waiting and in hope of getting better SNR**
 - OLT will improve ADC calibration, improve timing recovery, and adaptation!

Excessive Overshoot/Undershoot can Result in FEC Tail

❑ Currently TDECQ doesn't incorporate PAR (Peak to Average) penalty

- Without PAR penalty overshoot can drive the TDECQ lower while link BER degrades
- TDECQ not having PAR penalty the overshoot should be reduced <12% as receiver with DFE don't require such large overshoot!

Overshoot vs Rx performance



❑ Overshoot tends to improve sensitivity. It saturates for values larger than 22%

❑ Overshoot values larger than 22% increase error floor significantly

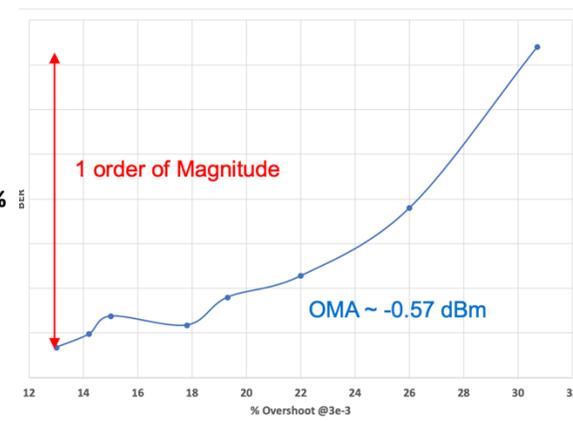
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8

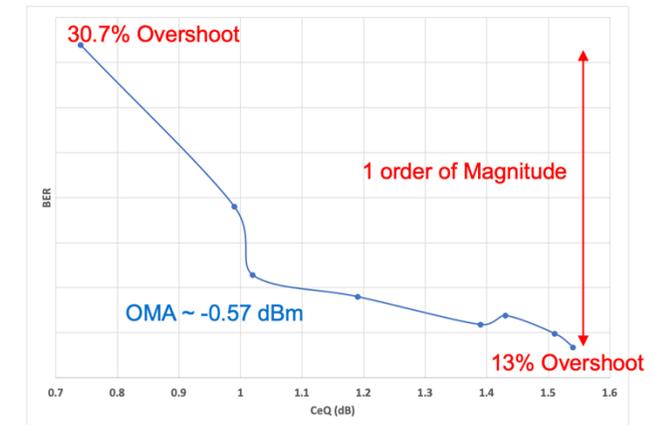
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Overshoot vs Ceq Protecting Receiver for Excess Overshoot

- Transmitter overshoot is a direct quantitative parameter protecting the receiver for excess pre-emphasis/overshoot



IEEE 802.3db Taskforce



[ghiasi_802.3db_01_092321](#)

11

Current Clause 178B ILT

□ Current copper E1 and optics O1 ILT capabilities

Table 178B-2—Control field structure for E1 interfaces

Bit(s)	Name	Description
15:14	Reserved	Transmit as 0, ignore on receipt
13:11	Initial condition request	13 12 11 1 1 1 = Reserved 1 0 1 = Preset 6 0 1 1 = Preset 5 0 0 1 = Preset 4 1 1 0 = Preset 3 1 0 0 = Preset 2 0 1 0 = Preset 1 0 0 0 = Individual coefficient control
10	Continue training	1 = Continue training 0 = Switch to data when training is completed
9:8	Modulation and precoding request	9 8 1 1 = PAM4 with precoding 1 0 = PAM4 without precoding 0 1 = Reserved 0 0 = PAM2
7	Reserved	Transmit as 0, ignore on receipt
6:5	Training pattern request	6 5 1 1 = free-running PRBS31 1 0 = Reserved 0 1 = free-running PRBS13 0 0 = synchronous PRBS13
4:2	Coefficient select	4 3 2 1 0 0 = Reserved 1 0 1 = $c(-3)$ 1 1 0 = $c(-2)$ 1 1 1 = $c(-1)$ 0 0 0 = $c(0)$ 0 0 1 = $c(1)$ 0 1 x = Reserved
1:0	Coefficient request	1 0 1 1 = No equalization 1 0 = Decrement 0 1 = Increment 0 0 = Hold

Table 178B-3—Control field structure for O1 interfaces

Bit(s)	Name	Description
15:11	Reserved	Transmit as 0, ignore on receipt
10	Continue training	1 = Continue training 0 = Switch to data when training is completed
9:8	Modulation and precoding request	9 8 1 1 = PAM4 with precoding 1 0 = PAM4 without precoding 0 1 = Reserved 0 0 = PAM2
7	Reserved	Transmit as 0, ignore on receipt
6:5	Training pattern request	6 5 1 1 = free-running PRBS31 1 0 = Reserved 0 1 = free-running PRBS13 0 0 = synchronous PRBS13
4:0	Reserved	Transmit as 0, ignore on receipt

Enabling Presets for Optical O1 PMDs

- AUI and KR/CR already support Presets and enabling optional Presets for O1 PMDs is straight forward as shown below but we may want to call it O2.

Table 178B-3 Control field O1 supporting optional Presets

Bit(s)	Name	Description
15:14	Reserved	Transmit as 0, ignore on receipt
13:11	Initial condition request (new item to support Preset)	13 12 11 1 1 1 = Reserved 1 0 1 = Preset 6 1 1 0 = Preset 5 1 0 0 = Preset 4 0 1 1 = Preset 3 0 1 0 = Preset 2 0 0 1 = Preset 1 0 0 0 = Reserved
10	Continue training	1 = Continue training 0 = Switch to data when training is completed
9:8	Modulation and precoding request	9 8 1 1 = PAM4 with precoding 1 0 = PAM4 without precoding 0 1 = Reserved 0 0 = PAM2
7	Preset Supported (needed only if support of Preset is Optional)	0 = Preset not supported 1 = Preset supported
6:5	Training pattern request	6 5 1 1 = free-running PRBS31 1 0 = Reserved 0 1 = free-running PRBS13 0 0 = synchronous PRBS13
4:0	Reserved	Transmit as 0, ignore on receipt

Table 178B-5 Status field O1 supporting Presets

Bit(s)	Name	Description
15	Receiver ready	1 = Training is complete and the receiver is ready for data 0 = Request for training to continue
14	ILT	Transmit as 1
13:12	Training pattern status	13 12 1 1 = free-running PRBS31 1 0 = Reserved 0 1 = free-running PRBS13 0 0 = synchronous PRBS13
11:10	Modulation and precoding status	9 8 1 1 = PAM4 with precoding 1 0 = PAM4 without precoding 0 1 = Reserved 0 0 = PAM2
9	Receiver frame lock	1 = Frame boundaries identified 0 = Frame boundaries not identified
8	Initial condition status (new item to support Preset)	1 = Updated 0 = Not updated
7	Parity	Even parity bit
6:0	Reserved	Transmit as 0, ignore on receipt

How to Configure the Presets

- ❑ **Need to enable the DME bits to enable Presets and decide if support of Presets is optional or mandatory – if optional then it defats the purpose**
 - AUI and CR/KR have enabled 6 Presets with 2 reserves
 - In DS all all 8 Presets can be enabled
- ❑ **How one may configure the Presets**
 - Following Preset configuration allow for overshoot adjustment, OMA, and inner/outer eyes if required or Preset table can be simplified to fewer settings:
 - Preset 1 – Default optimized for mid-reach with moderate overshoot – Only setting that TDECQ must be met
 - Preset 2 – Optimized for short reach with low overshoot
 - Preset 3 – Optimized for long reach with high overshoot
 - Preset 4 – Lower OMA by 1 dB
 - Preset 5 – Increase upper eye by 1%
 - Preset 6 – Increase lower eye by 1%
 - Preset 7 – Decrease upper eye by 1%
 - Preset 8 – Decrease lower eye by 1%

OMA adjustment and outer eye adjustment are applied to Preset 1, 2, or 3.

Requesting Preset 1, 2, 3 will reset these settings.

If Preset 4 is requested twice the OMA will be lowered by 2 dB (Presets 4-8 are additive).

Alternate Way to Configure the Presets

□ Configuration enable Presets and individual tap control as in case of E1 – TX FFE can be assumed to have 5 taps 2 pre and 2 post (E1 ILT has 3 pre and one post)

– Preset 1-4 are similar to KR/CR starting point for iterative tap adjustments:

- Preset 1 – Optimized for mid-reach with moderate overshoot
- Preset 2 – Default with no-equalization full power
- Preset 3 – Default with no-equalization at -1.5 dB power
- Preset 4 – Default with no-equalization at -3.0 power
- Preset 5 – Increase upper eye by 1%
- Preset 6 – Increase lower eye by 1%
- Preset 7 – Decrease upper eye by 1%
- Preset 8 – Decrease lower eye by 1%

– Only setting that TDECQ must be met
Requesting Preset 1, 2, 3, 4 can be used as the starting point for individual pre/post tap adjustment.

Preset 5-8 are for inner/outer eye adjustments if requested twice the the inner/outer eyes are incremented by 2% and are additive, If Preset 1-4 are requested then inner/outer eye gets reset.

Other Potential OLT Capabilities

- ❑ **OLT baseline with 4 pages will have sufficient space that future projects may choose to control various type of optical parameters to improve optical link performance and/or reach – not part of current proposed baseline**
 - Preset in classical ILT only used for FFE adjustment
 - Adjusting transmit FFE taps autonomously (pre-emphasis) or Overshoot – important for VCSELs
 - OMA control – maybe not as important for VCSELs
 - Inner/Output Eye Adjustment - important for VCSELs
 - MZM compression – NA for VCSELs
 - EA modulators asymmetrical compression – NA for VCSELs
 - CD penalty on links $> 2\text{km}$ on outer wavelengths L0 and L3 – NA for VCSELs
- ❑ **Some of the above controls may impact baseline TDECQ which doesn't always produce the best BER, as long as adjustment are not disruptive the receiver MMSE will converge to the best link BER.**

Summary

- ❑ **Current TDECQ reference receiver doesn't incorporate effects such as compression and ADC ENOB, and there is no penalty for degradation due to non-linearities**
 - TDECQ improves with increasing overshoot often drives link to lower TDECQ which may not result in optimum block BER – on going effort in 802.3dj to fix this issue
- ❑ **Enabling ILT O1 PMDs Presets is straight forward and control field 7 can be used to advertise optional Presets support**
 - Defining expanded ILT capabilities as optional defeat the purpose
 - Better option is for transmitters to support expanded ILT but receiver optionally use these capabilities
- ❑ **The key question is what transmitter adjustments provide at least an order of magnitude improvement in BER improvement for 200G MMF**
 - Are few smart overshoot settings with some post and pre sufficient compared to individual pre/post tap adjustments?
 - What is the overall benefit of adjusting inner/outer eyes?
- ❑ **There are several possible path from enabling Presets to enabling Presets and tap control like Copper PHYs!**

Back up