Potential Knobs for Optical ILT

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Overview

- Potential benefits of ILT for optics
- Current E1 and O1 ILT frames
- How to enable Presets
- How to enable OMA control
- Other useful control
- Summary.

Potential OLT Knobs One May Adjust

- **Adjustment of optical parameters that may improve optical link performance and/or reach**
  - Preset in classical ILT only used for FFE adjustment
    - Adjusting transmit FFE taps autonomously (pre-emphasis) or Overshoot – important for any device with sub-90 GHz BW
  - OMA control – reduces AGC requirements and the need for VOA in front of PD
  - Inner/Outer Eyes Adjustment - important for EA modulators/VCSELs
  - MZM compression – important for any MZM modulator with symmetrical compression
  - CD penalty – applicable to all 400G links ≥ 500 m
- **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 select best operating point**
  - The key is to make sure the receiver can cycle through the Preset or other controls with transmitter output stabilized in ≤TBD (10-30 ms) time.

Current Clause 178B APSU

❑ Current clause 178B copper E1 and optics O1 control fields

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

Current Clause 178B APSU

❑ Current clause 178B copper E1 and optics O1 status fields

Table 178B–4—Status field structure for the E1 format

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	Reserved	Transmit as 0, ignore on receipt
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	11 10 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	1 = Updated 0 = Not updated
7	Parity	Even parity bit
6	Reserved	Transmit as 0, ignore on receipt
5:3	Coefficient select echo	5 4 3 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
2:0	Coefficient status	2 1 0 1 1 1 = Reserved 1 1 0 = Coefficient at limit and equalization limit 1 0 1 = Reserved 1 0 0 = Equalization limit 0 1 1 = Coefficient not supported 0 1 0 = Coefficient at limit 0 0 1 = Updated 0 0 0 = Not updated

Table 178B–5—Status field structure for the O1 format

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	Reserved	Transmit as 0, ignore on receipt
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	11 10 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	Reserved	Transmit as 0, ignore on receipt
7	Parity	Even parity bit
6:0	Reserved	Transmit as 0, ignore on receipt

How to Configure the Presets

- **Recommend to define 3 mandatory Presets (1, 2, 3) and 3 optional Gray Presets set by the manufacture for best performance/BER**
  - AUI and CR/KR have enabled 6 Presets
  - In DS we are proposing to enable 3 presets
- **Enabling 6 Presets for 802.3dv optical PMDs**
  - Following Preset configuration allow for overshoot adjustment, OMA, and inner/outer eyes if required or Preset table can be simplified to fewer settings:
    - Preset 0 – Individual coefficient control
    - Preset 1 – Default with up to 27% overshoot must meet TECQ/TDECQ and FRx
    - Preset 2 – with up to 20% overshoot only needs to meet FRx
    - Preset 3 – with up to 14% overshoot only needs to meet FRx
    - Preset 4 – Gray Preset with up to 27% Overshoot and only need to meet FRx
    - Preset 5 – Gray with up to 27% Overshoot and only need to meet FRx
    - Preset 6 – Gray with up to 27% Overshoot and only need to meet FRx
    - Preset 7 – Reserved
  - Preset 1, 2, and 3 are mandatory
  - Preset 4, 5, and 6 are optional where manufacture may configure based on their experience for best performance/BER
    - Manufacture that don't want to populate optional Gray Preset 4, 5, and 6 can populate these Presets with Preset 1 settings.

What Other Parameters Adjustment Provide Sufficient Benefit

- **Full autonomous control of TxFFE by the receiver brings with it significant risk and can push the device into non-linear region or into a region transmitter operation isn't guaranteed over PVT**
  - The transmitter space must be test to make sure its graceful with minimum impact on device OMA, linearity, and chirp over PVT
- **Other transmitter adjustment worth considering are:**
  - OMA control – careful few +/-0.5 dB steps with tolerance of TBD to allow TIA to operate at optimum gain and input power without requiring an integrated VOA/PD in front of the TIA
    - Assuming one uses a waveguide PD then VOA can be integrated in front of PD with ~0.5 dB of loss
  - Inner/Outer compression adjustment – may also provide sufficient benefit but require further investigation and currently not part of this proposal.

Enabling Presets and OMA Control for Optical PMDs

- **Items highlighted below are the E1 control and status fields to enable support for Presets and OMA control.**

Table 178B-3 Control field O1 to support Presets and OMA Control

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 = For OMA 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 (can be used to advertise BCET support)	Transmit as 0, ignore on receipt
4:2	Coefficient select	4 3 2 1 0 0 = Increase/decrease OMA by 0.5 dB 1 0 1 = Reserve 1 1 0 = Reserve 1 1 1 = Reserve 0 0 0 = Reserve 0 0 1 = Reserve 0 1 x = Reserved
1:0	Coefficient request	1 0 1 1 = Reserved 1 0 = Decrement/Decrease 0 1 = Increment/Increase 0 0 = Hold

Table 178B-5 Status field O1 to Support Presets and OMA Control

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	Reserved	Transmit as 0, ignore on receipt
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	1 = Updated 0 = Not updated
7	Parity	Even parity bit
5:3	Coefficient select echo	4 3 2 1 0 0 = Increase/decrease OMA by 0.5 dB 1 0 1 = Reserve 1 1 0 = Reserve 1 1 1 = Reserve 0 0 0 = Reserve 0 0 1 = Reserve 0 1 x = Reserved
2:0	Coefficient status	2 1 0 1 1 1 = Reserved 1 0 1 = Coefficient at limit 1 1 0 = Reserved 1 0 0 = Reserved 0 1 1 = Coefficient not supported 0 1 0 = Coefficient at limit 0 0 1 = Updated 0 0 0 = Not Updated

Summary

- **400G optical PMDs will benefit enabling APSU Presets and OMA**
  - Preset 1 is the default preset that TECQ/TDECQ and FRx are met with Max 27% overshoot
  - Preset 2 with Max 20% overshoot only needs to meet FRx
  - Preset 3 with Max 14% overshoot only needs to meet FRx
  - Preset 4, 5, and 6 are the gray Presets where manufacture may adjust for best BER and must meet FRx
  - Transmitter OMA is adjusted at +/-0.5 dB increment for optimum TIA SNR without needing a VOA
- **The current annex 178B ILT also can support adding compression adjustment on lower and upper eyes if that is necessary**
- **What BCET as proposed by Bruckman_3dv_01a_2611 may provide**
  - Read/write of the transmitter FFE taps
  - Provide additional Presets
  - Use of non-linear lookup tables for different transmitter technologies such EA, MZM, TFLN, and MRM then make the necessary non-linear adjustment
  - Transmitter can read the receiver SNR during ILT
  - Similar to OIF CMIS-LT where there are Basic and Advance link training, BCET can be an optional feature advertised by Control Field bit 7 for advance features.

Thank You