Compliance points for XLAUI/CAUI with connector

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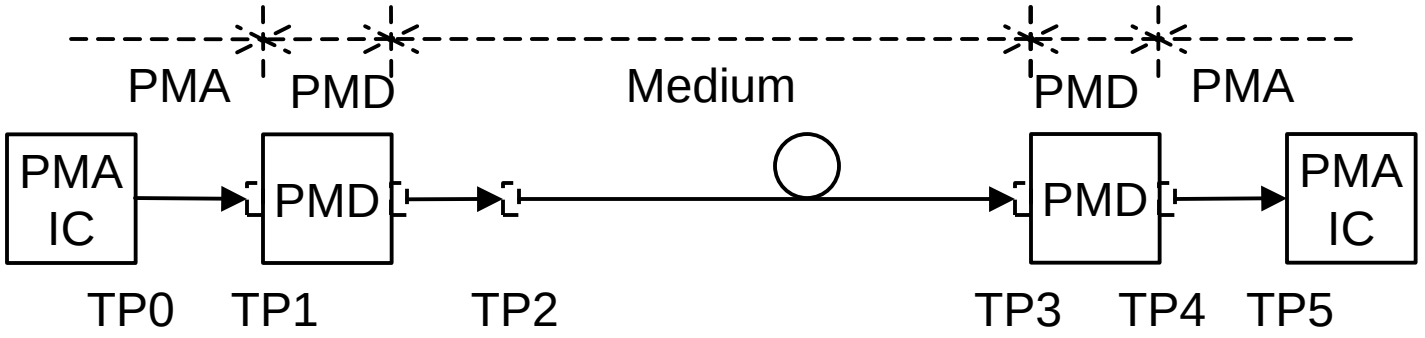
The basics



- Example: simplified test points for an optical link
  - e.g. Gigabit Ethernet with GBIC, Fibre Channel with SFP, 40GBASE-SR4 or 100GBASE-SR10 ("SRn") with PPI
  - All parts of the link are within a sublayer or the medium. There is no "no-mans-land".
  - Compliance points **MUST** be somewhere measurable
  - Compliance points relate to a connector
    - If you can't unplug something and plug in an alternative, you don't know or care what the analog signal is there
    - If the PCB loss is small enough (Gigabit Ethernet) and there are no skew specs, the difference between TP0 and TP1 doesn't matter

TP2 is displaced from the MDI to get a more consistent measurement. The signal at TP2 is representative of the effective signal launched into the fibre.

Purpose of test points

- For compliance testing
  - Must be accessible
  - S-parameters e.g. reflection, transmission specs of a cable
    - Microwave de-embedding is feasible; measurement can be done at a distance to specification point
  - Including sensitivity, eye diagrams and similar with nonlinear electrical-optical converters (PMDs, optical modules)
    - Microwave style de-embedding is not feasible
- For interoperability
  - Must be related to connectors
- For precise results
  - As frequencies increase and higher performance product is specified, have to be more particular about test point definition
  - See backup for test points used in other projects

Electrical connector is significant

- Connector provides something that can be unplugged to observe the signals – a compliance point
- Connector probably has better reflections than IC package but worse(?) crosstalk
- But even if better, it's still additional impairment

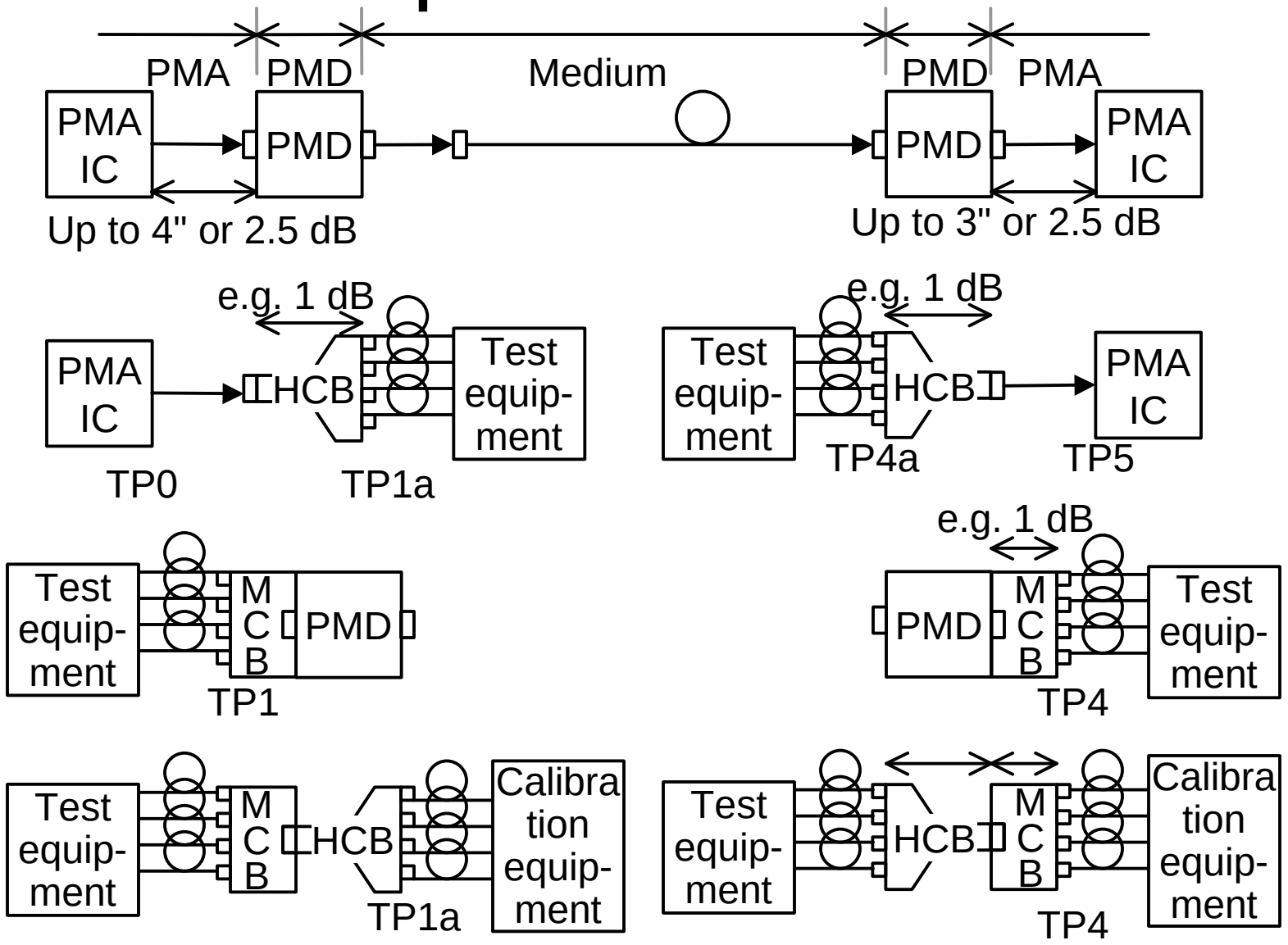
Comparison of connector and IC specs

At 5.15625 GHz	Reflection (max, dB)	Near end crosstalk (max, dB)
nAUI compliance point	–6.9	No spec
SFP+ ASIC (informative)	–8.5	No spec
Proposed connector spec (Cole, reflector message)	–21	–36
SFF-8083 (for SFP+)	–14.6	–35 (D1.5)

Connector loss assumed <=0.5 dB at 5.15625 GHz

This page is for information – not a proposal

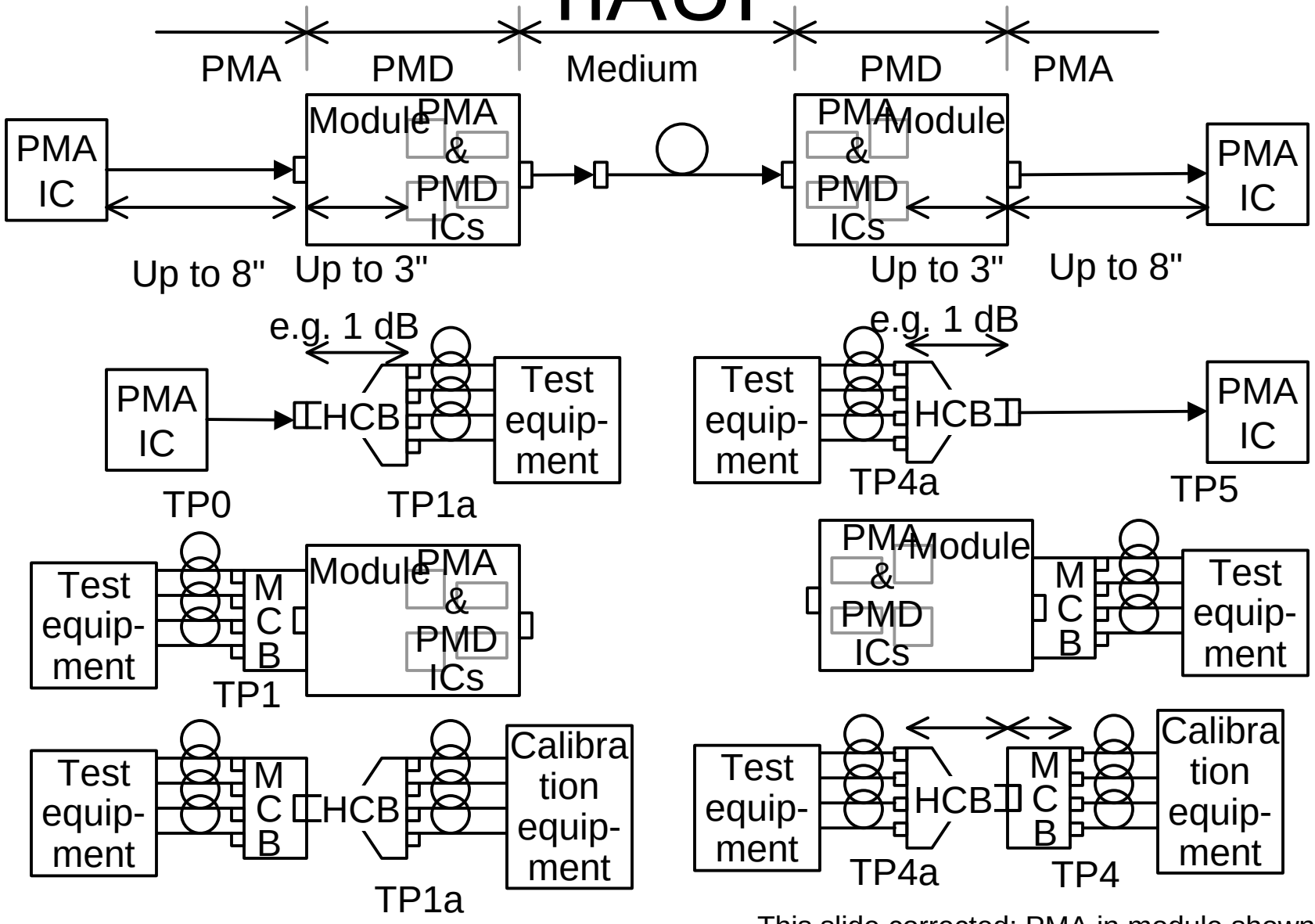
Compliance boards



Compliance boards – notes

- Host Compliance Board (HCB) and MCB (Module Compliance Board) convert between module connector format and instrumentation connectors (e.g. SMA)
- Compliance boards have defined S-parameters
  - Not representing the product PCB loss but a small loss that can be conveniently and reproducibly made
  - Between 1 and 1.5 dB at Nyquist frequency (5.15625 GHz)
- Cannot de-embed PCB losses for e.g. eye and sensitivity measurements. Cannot ignore test board loss
  - This is the reason that compliance board approach is necessary
- Coax cable loss/in is much less than test board loss/in
  - This is the underlying reason why compliance board approach is useful
- Signals are defined after the connector, always
- Reflective S-parameters of sublayer under test are defined looking through compliance board at sublayer (a PMA for nAUI) under test

nAUI



This slide corrected: PMA in module shown

nAUI – notes

- Compliance points are not far from the PMD IC
- Compliance points could be far from the PMA IC
- Compliance points as defined for PPI are very suitable
  - No need for new definitions
  - Hope that the compliance board losses can be the same as for PPI, even if connector is physically different
- Compliance board specs are electrical only – do not define product electrical connector choice

nAUI loss budget

- PCB loss within PMA is a private matter between IC implementer and host PCB implementer
- Standard can recommend no more than the loss of 3" in the module
  - Variously estimated as 1.7 dB to 2.6 dB
- And 8" in the host
  - 4.6 to 7 dB
  - But implementers will try to stretch the length
- Proposed reference budget at 5.15625 GHz
  - Module PCB 3" 2.5 dB
  - Module connector - 0.5 dB
  - Host PCB 8" 7 dB
  - Total 10 dB

How to spec the signal

- On transmit side,
  - Signal at compliance point is similar to signal at point of use because loss between them is small
  - An open eye at TP1a is enough to ensure a usable signal at PMD's point of use
  - But point of generation could be significantly displaced (upstream) by frequency-dependent loss
  - Implies quite a lot of emphasis at TP0: will this cause too much crosstalk? SFP+ does this, for 6.5 dB loss budget but much more demanding jitter requirements
  - If necessary, could let the observed eye be slower
- On receive side
  - Signals could be significantly displaced by frequency-dependent loss
    - Do we want to require the eye at the connector to have a minimum (pre)-emphasis?
    - Should not fully compensate the lossiest channel because of crosstalk

How complicated an implementation?

- We don't specify these but we make assumptions to write signal specs
- 1-tap emphasis at each driver and 1-tap DFE at each receiver expected to work
- The 1-tap DFE in module (PMD transmit-side receiver) could be deleted (as assumed in SFP+) as an implementation choice
    - e.g. if module traces have low loss
    - Does the same go for module receive-side driver?
  - Two? transmit emphasis settings programmed into ICs
    - Factory knows the PCB the IC has been soldered into
  - Two (in practice often one) receiving 1-tap DFEs
    - Need to tolerate the loss from the connector
    - Could tune autonomously (adaptive), could be set by manufacturer

Options for specifying emphasis

- Add TWDP and UJ specs on receive side
  - We know how to do this – used in 8G Fibre Channel
  - Use PRBS9, waveform capture and analysis
  - Use a software representation of the 8" PCB
    - Do we need both with and without software channel?
      - Just post-processing, not another measurement
  - Do we need a Qsq spec also?
- Or, specify emphasis via overshoot
  - Also could use PRBS9
  - Doesn't relate so directly to usable performance
  - Need UJ and/or Qsq specs
- Other options?

What if there isn't a connector?

- If there's no connector, implementer can do as he pleases because compliance tests can't catch him out
- But can use ICs intended for use with connector
- Suggestion: make evaluation boards for each IC with part of expected PCB loss + compliance board loss
  - The two parts of loss add up to actual PCB loss
  - Implementer gets to choose where his observation point is: near one end, or the other, or the middle
- Either: if meet the specs, it's OK to 10^-12
- Or: if meet the specs with margin, it's OK to 10^-15
- 10^-15 not an Ethernet objective – don't write about it in 802.3 standard
- If 2 connectors: pick one as the compliance connector and proceed
  - Connectors and/or ICs have to be proportionately better to meet the specs

Conclusions

- Compliance Board methodology is ideal for nAUI-with-connector spec
- A total loss budget of 10 dB is a good starting point
- Transmit side signal can be specified by "conventional" (not equalisation-aware) methods
- Receive side signal needs a little more
  - Recent successful experience in SFP+ and 8G Fibre Channel can guide us quickly to a good specification

Backup

- Next two slides describe the test points used in Gigabit Ethernet, Fibre Channel, SFP+ and XFP
- See also http://ieee802.org/3/ba/public/sep08/dudek_01_0908.pdf which contains more diagrams of SFP+ compliance board use

Background 1/2

- TP1, TP2, TP3, TP4 in Clause 38 (Gigabit Ethernet) is well known
  - TP1, electrical: host output, module input
  - TP2, module optical output
    - Actually, 2 m after the MDI
  - TP3: module optical input
  - TP4, electrical: module output, host input
  - TP0, TP5 have been used informally for a some time (at IC within host)
- Clause 39, CX4, also has TP1, TP2, TP3, TP4 (all electrical)
  - TP1: upstream of transmit MDI
  - TP2: just downstream of transmit MDI
  - TP3: just upstream of receive MDI
  - TP4: downstream of receive MDI

"It is expected that in many implementations TP1 and TP4 will be common between 1000BASE-SX (Clause 38), 1000BASE-LX (Clause 38), and 1000BASE-CX"

Background 2/2

- Fibre Channel up to 4GFC has alpha gamma delta (α_T δ_T γ_T γ_R δ_R α_R)
  - For an optical link,
  - α_T: Output of IC in host
  - δ_T: host output, module input, just upstream or just downstream of module transmit electrical connector
    - Depending on what is to be tested
  - γ_T: module optical output, 2 m after the MDI
  - γ_R: module optical input
  - δ_R: module output, host input, just upstream or downstream of module receive electrical connector
    - Depending on what is to be tested
- For 8GFC, "just upstream or just downstream" is taken to mean the input or output of a compliance board with a defined electrical loss
- SFP+ compliance points are the same as 8GFC but with different names
- XFP compliance points are earlier, less thorough, version of SFP+'s