AC coupling and impedances in Tx/Rx electrical test setups

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Outline

- Transmitter test setups in earlier clauses
- Test specifications in 802.3cd and other recent projects
- Implications
- Suggested remedies

Transmitter test setup in Clause 72

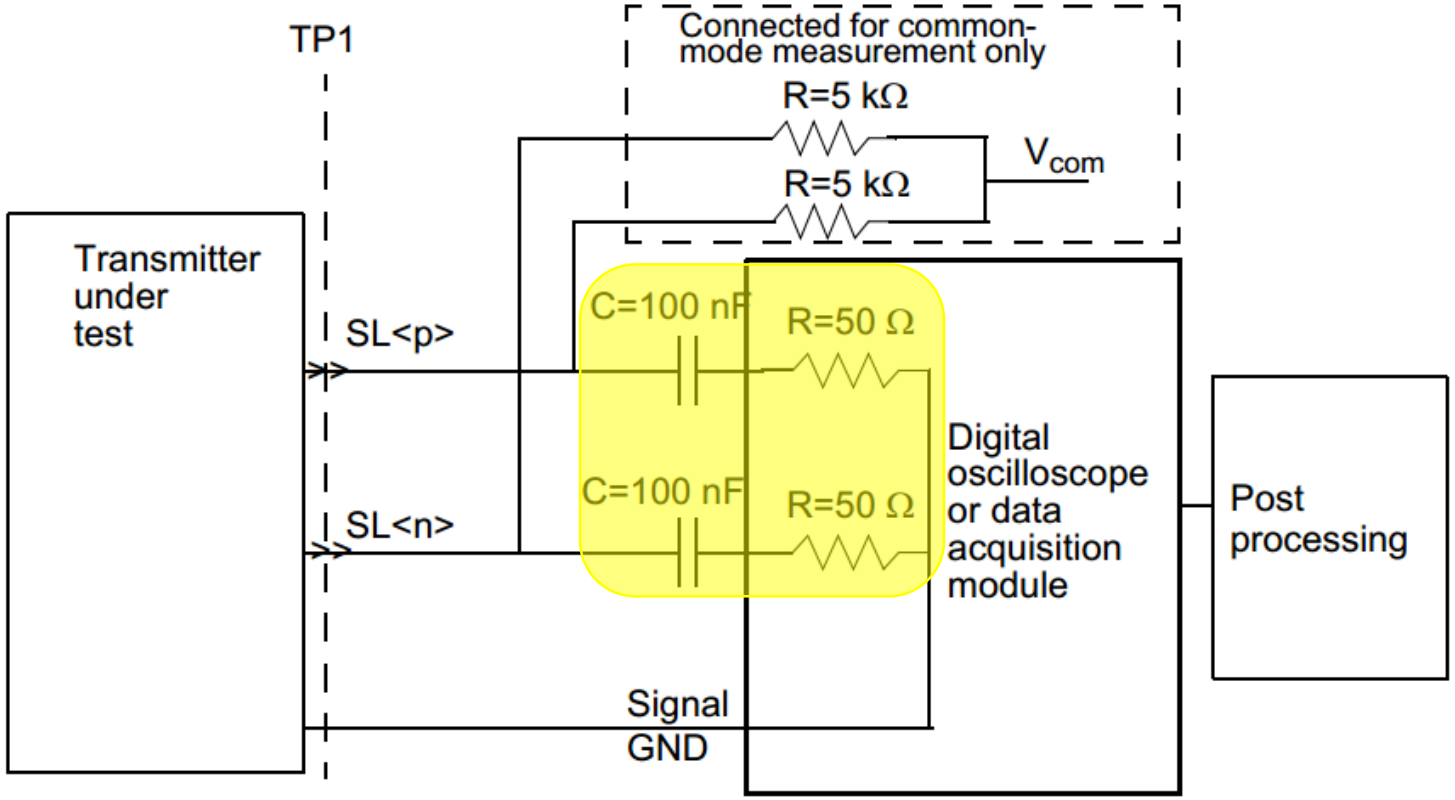

Figure 72–7—Transmit test fixture for 10GBASE-KR

Transmitter test setup in Clause 85

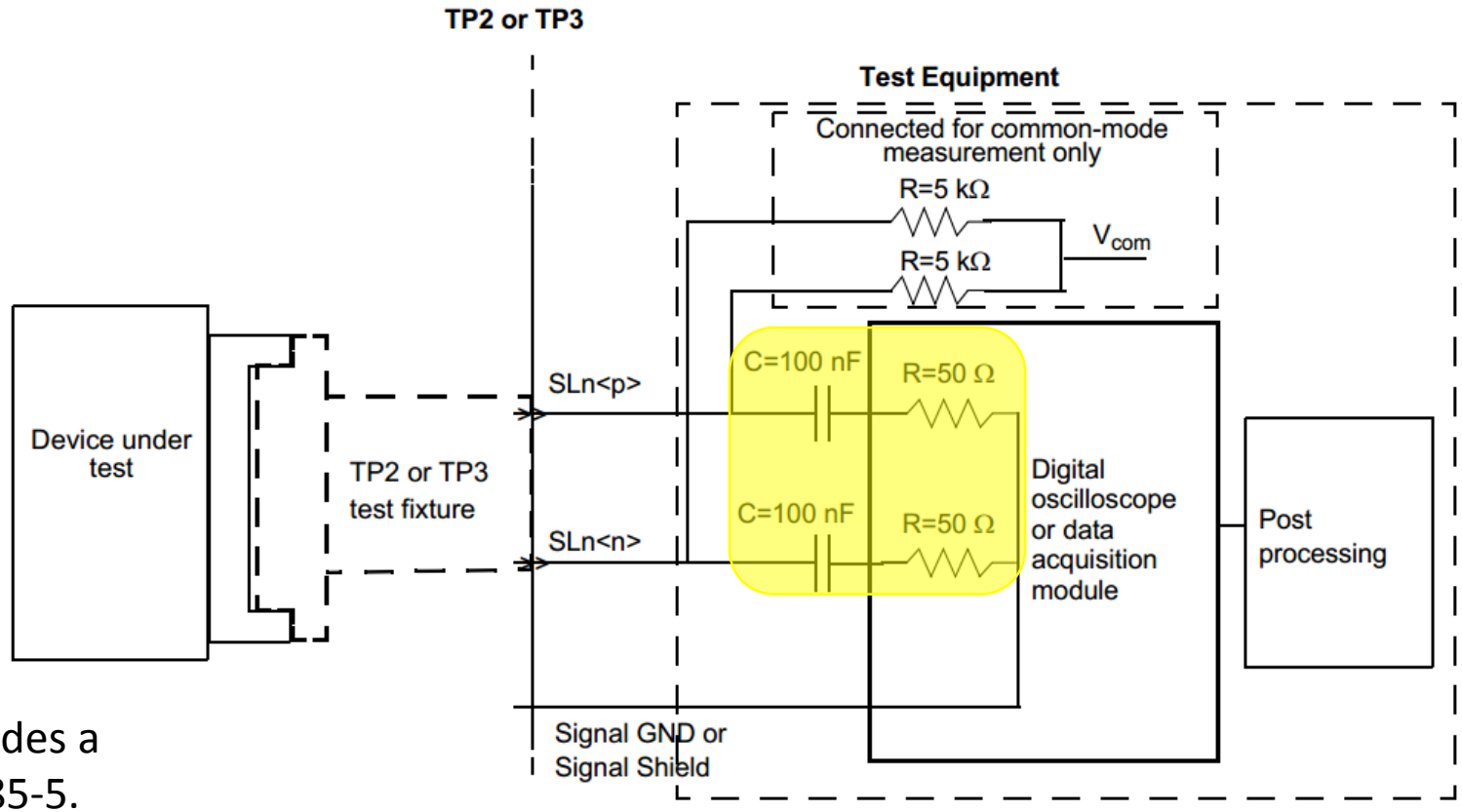

Figure 92–15—Transmitter and receiver test setup

Clause 85 includes a similar Figure 85-5.

Why is AC coupling important?

AC coupling enables any common mode voltage between SL<p> and SL<n>, isolated from the Rx CM (no DC current).

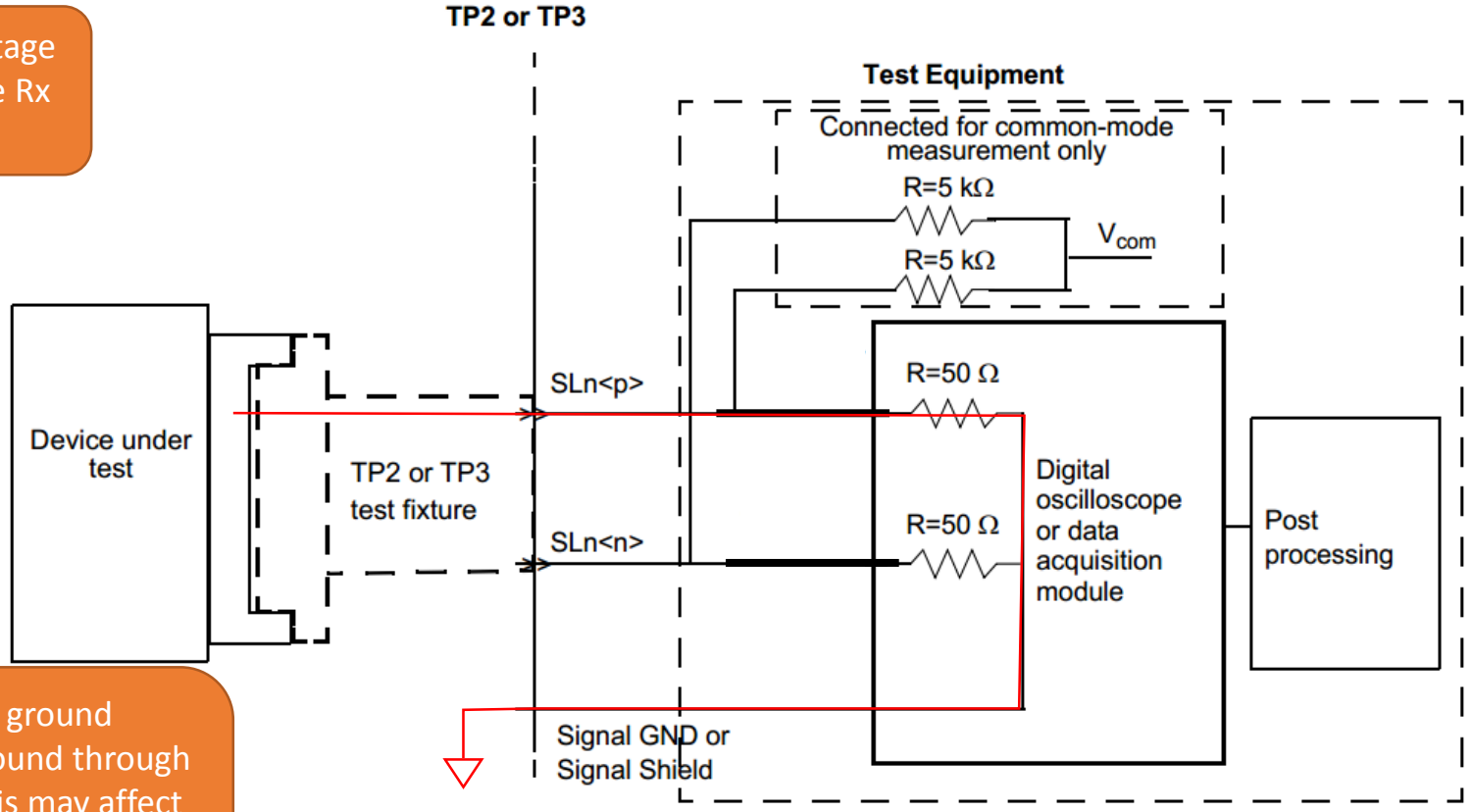

Figure 92–15—Transmitter and receiver test setup

With DC coupling the CM is forced to the ground voltage; The Tx circuit is connected to ground through 50Ω, creating unexpected DC current. This may affect performance and potentially damage the circuit.

(Similar argument for the Rx)

Tx test specifications in 802.3cd

- Clause 136 does not have a similar test setup description… what does it have?
  - **136.9.1 AC-coupling**
    Interoperability between PMD components operating from different supply voltages is facilitated by AC-coupling within the cable assembly plug connectors (as specified in 136C.1).
  - **136.9.3 Transmitter characteristics**
    The transmitter on each lane shall meet the specifications given in Table 136–11 and detailed in the referenced subclauses. Unless specified otherwise, all transmitter measurements are made for each lane separately, at TP2, utilizing the test fixtures specified in Annex 136B, using a test system with a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth.
  - **136.9.3.1.1 Linear fit to the measured waveform**
    (…) For each configuration of the transmit equalizer, capture at least one complete cycle of the test pattern at TP2, as specified in 85.8.3.3.4.
- So, one might understand that the test setup from clause 85 (with AC coupling) should be used…
  - But this is stated very indirectly and only for the linear fit procedure (e.g. not for jitter measurement).
- Clause 137 only refers to Annex 120D (in 802.3bs) which has a similar reference to 85.8.3.3.4 in the linear fit procedure.
- Annexes 135B, 135D, 135F also point to Annex 120D (as in Clause 137)
- Annexes 135C, 135E, and 135G point to 120E which clearly shows AC coupling in the corresponding diagram.

Tx test specifications in 802.3bs

- In 120D.1, AC coupling is mentioned:

  Each data path contains four AC-coupled differential lanes using PAM4 signaling, where the highest differential level corresponds to the symbol three and the lowest level corresponds to the symbol zero. The low-frequency 3 dB cutoff of the AC-coupling should be less than 100 kHz.

  but it is unclear whether it is a part of the Tx, the Rx, or the channel. (Note that 137.10 states that "Channels shall have AC-coupling as specified in 93.9.4."
- 120D.2 has definition of compliance points (TP0a and TP5a), which refers to Figure 93-5. This figure does not include test equipment or AC coupling.
- There is no other description of the Tx test setup, and no mention of AC coupling or of the scope impedance in the test. There is only a reference to 85.8.3.3.4 (as in clause 136) in the linear fit procedure.
- 120E has no such issues (as will be shown).

Did this issue exist earlier?

- Annex 83A specifies AC coupling as part of the Rx (83A.3.5.5). The Tx measurement setup is not described at all.
- In Clause 93: the test system is not shown in Figure 93-5
  - DC coupling in the test may be implied…
  - Carried over to C2C Annexes 83D and 120D (which point to Figure 93–5).
- The C2M Annexes 83B, 83E, and 120E specify that the AC coupling is within the module, and the host Tx compliance point (TP1a) is at output of the HCB (which does not include AC coupling). However, AC coupling is clearly shown in the host output test setup diagram in 83E and 120E. (83B has no such diagram)
- Clauses 84, 110, and 111 and Annexes 109A-B, 120B-C and 135B-G only point back to other clauses.
- Note that **host input** test setup diagrams include “DC blocks” in most cases, e.g. Figure 83E–14. The only exception is Figure 83B–10.
- Annex 93C which defines the RITT setup for backplane and C2C (used in Annex 120D and other places) does not mention AC coupling.

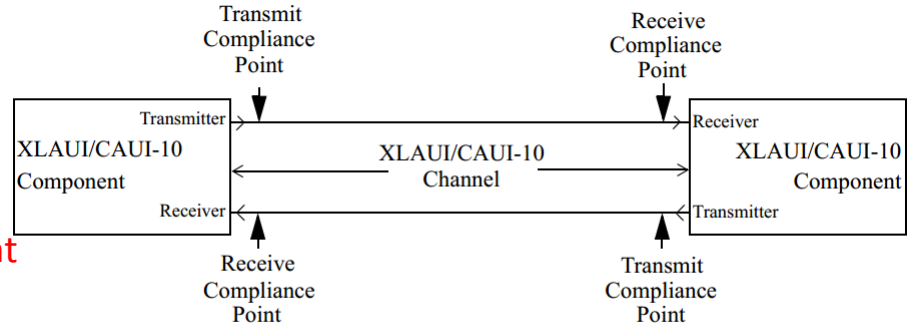

Figure 83A–2—Definition of transmit and receive compliance points

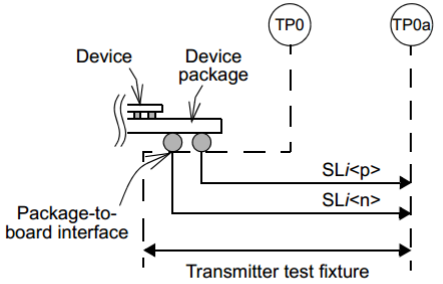

Figure 93–5—Transmitter test fixture and test points

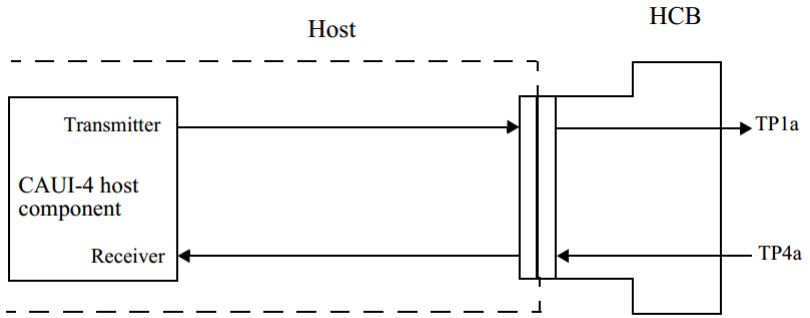

Figure 83E–4—Host CAUI-4 compliance points

C2M Host input test setup diagram

Good way (in most cases)

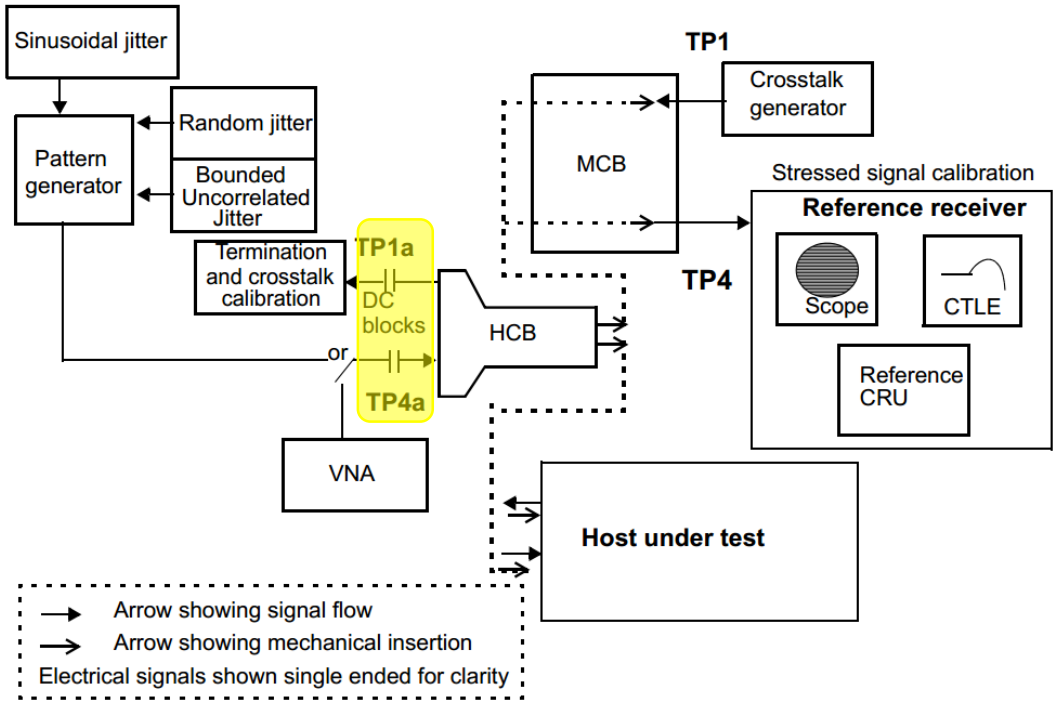

Figure 83E–14—Example host stressed input test

Bad way (only 83B)

AC coupling missing here

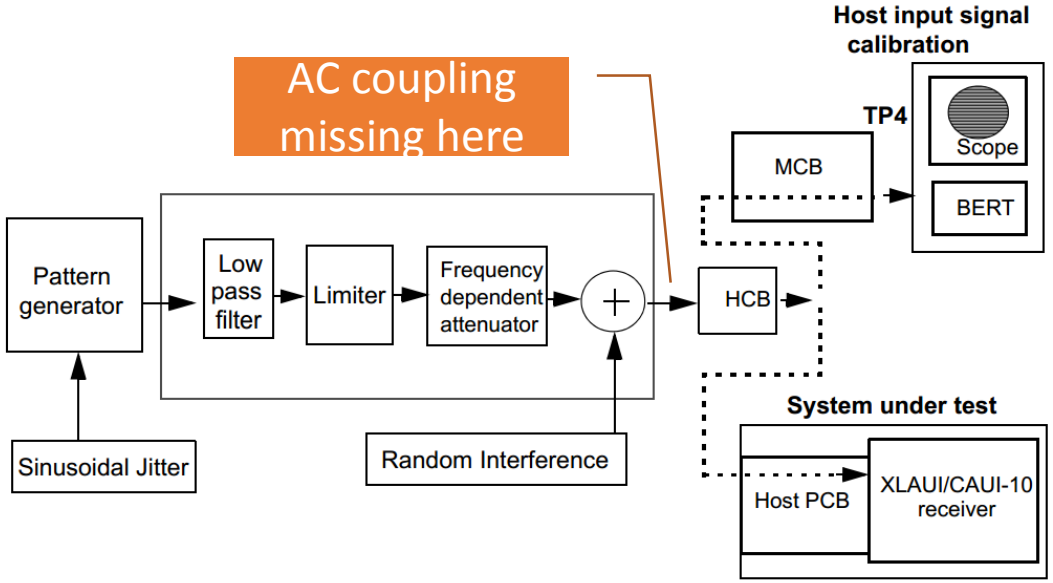

Figure 83B–10—Stressed-eye and jitter tolerance test setup

C2M Host output test setup diagram

Good way

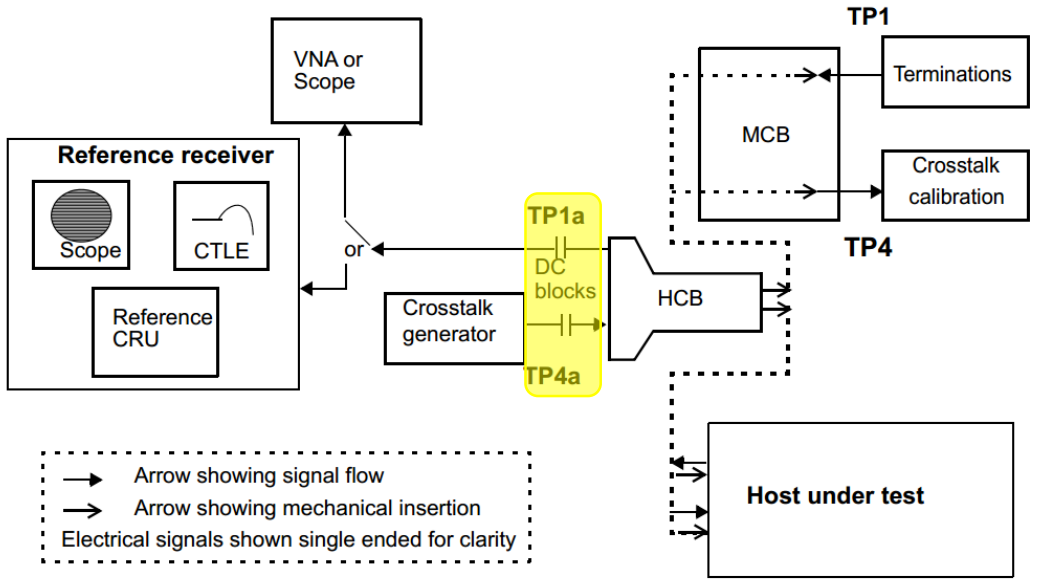

Figure 83E–9—Example host output test configuration

- (no equivalent in 83B)

Implications

- AC coupling is explicitly shown in some places and omitted in others…
- I have encountered many questions about this since 802.3by was published. Examples:
  - Should “KR” and AUI Tx meet their specifications without AC coupling? (no)
  - Is AC coupling considered part of the Tx test fixture (TP0-TP0a) in the “KR” specs? Should it be within the HCB in the “CR” specs? (no)
  - If not, is it in the test setup? Should we use coaxial “DC block”? Is AC coupling of the scope OK?
- There are IL/RL specs for the Tx board and the mated test fixture that may be affected by design choice.
- Different setups may yield different results…

Suggested remedy for P802.3cd

- In Clause 136, apply the following change

136.9.3 Transmitter characteristics

The transmitter on each lane shall meet the specifications given in Table 136–11 and detailed in the referenced subclauses. Unless specified otherwise, all transmitter measurements are made for each lane separately, at TP2, utilizing the test fixtures specified in Annex 136B, using a test system with a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth connected as shown in Figure 92–15.

- All other clauses and annexes point back to existing clauses so should be handled through maintenance.

Proposed changed in maintenance (1)

- Clause 93 would best be fixed by adding the AC-coupled scope connection in Figure 93-5 (see next slide).
- This fix will also apply to several other places that reference clause 93 directly or indirectly (Annexes 83D, 109A, 120B, 120D, 135B, 135D, 135F, and Clauses 111 and 137).

Concept of suggested change in Figure 93-5

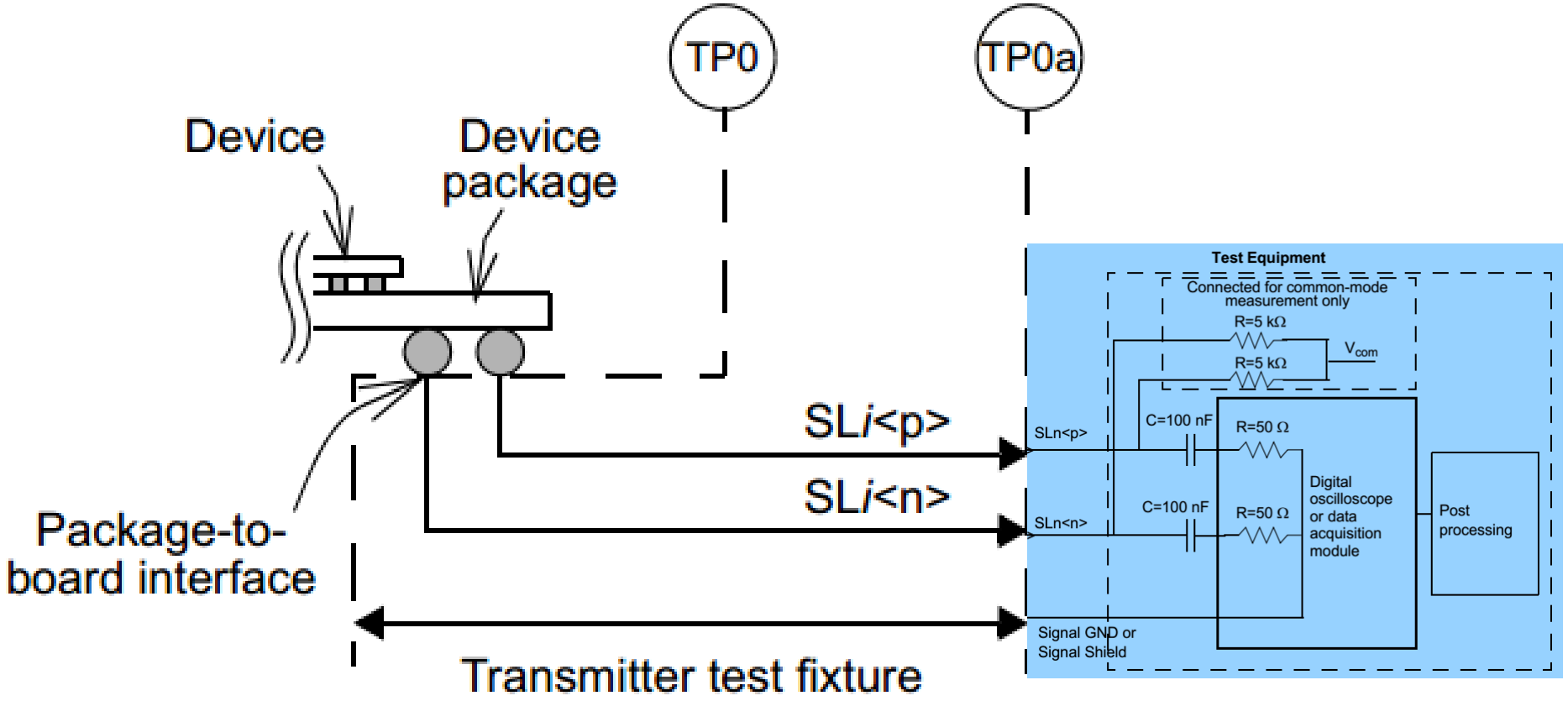

Figure 93–5—Transmitter test ~~fixture and test points~~ setup

Proposed changed in maintenance (2)

- To handle AC coupling in RITT, in Annex 93C, apply the following change:
  - The transmitter is functionally and parametrically compliant to the requirements of the invoking PMD clause. The ISI channel emulates the frequency dependent loss of a backplane channel. The channel noise source emulates crosstalk, transmitter noise, and unequalizable signal distortions introduced by a channel. AC-coupling as indicated by the invoking PMD clause is included either in the TP5a to TP5 trace or in the ISI channel.
- Annexes 83A and 83B are not affected by the proposed changes
  - Old 10 GBd specifications – are they worth fixing?
  - Figure 83B-10 should be easy to fix, but there is no Tx test setup diagram

That’s All Folks!

Questions?