Consensus proposal for Rx tolerance tests changes in clauses 110 and 111

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Background

- Issues with interference tolerance tests were identified gradually during working group ballot.
- Following the October interim some of us started discussions trying to identify and address all remaining issues.
- Consensus building process after the November meeting.
- **18 Participants:**
  - Matt Brown, Piers Dawe, Chris DiMinico, Curtis Donohue, Mike Dudek, Oran Gafni, Ali Ghiasi, Mike Klempa, Kumaran Krishnasamy, Greg LeCheminant, Rich Mellitz, Tom Palkert, Adee Ran, Upen Reddy Kareti, Alexander Rysin, Steve Sekel, Omer Sella, Phil Sun
- **3 key presentations:**
  - “802.3by 25G CR Rx ITT/JTT Proposal” – Oran Gafni
  - “Cable RITT” – Rich Mellitz
  - “Revised rise-time filter for COM interference tolerance calibration” – Mike Dudek

Main goals

- Clarify clause 110 test setup, channel construction and reference points
  - Started in D2.3 but requires more work.
  - Comments i-28, i-36, i-37, i-42, i-71, i-74 (+ others)
- Clarify test channel COM calculation in both clauses
  - Some parameters are missing.
  - Comment i-66 (+ others)
- Address transition time filter issues in both clauses
  - Equations used in 802.3bj do not yield the expected results.
  - Comments i-24, i-57, i-61, i-88 (+ others)
- Enable using either compliant 25GBASE-KR devices or test instruments as transmitters for RITT
  - To simplify test setup and improve commonality between clause 110 and clause 111 methods.
  - Comment i-51 (also intended to serve all consensus building results)

Conventions in this presentation

- Blue text or blue background: suggested new content or modifications
- Red text: Suggested deletion

- Text in Times font: text to be used verbatim; otherwise, implement with editorial license
- ★: denotes a change from the original consensus presentation

Test setup, reference points

- Test channel construction is per Figure 110–3
  - Cable assembly: specify range of CA fitted IL @12.8906 GHz in each table
    - Test 1: no less than minimum (from Table 110A–1), and within 2 dB of that minimum
    - Test 2: no more than maximum per CA type (from Table 110A–1), and within 2 dB of that maximum
  - "Additive host board loss"
    - Rename to "Frequency-dependent attenuator".
    - Add NOTE: "The frequency-dependent attenuator represents the host channel and may be implemented with PCB traces and test cables".
- The term "PGC" should be changed to "Tx test reference"
  - Noise is added before and measured at the Tx test reference
  - Noise combiner effects, such as flat loss or reflections, are part of the test transmitter.
- Rx test reference is after a CA test fixture.
- In 110.8.4.2.2 (test channel), set first sentence to

  The test channel (depicted in Figure 110-3) consists of the following:
- (See later slide for proposed updated figures)

Clause 110 test channel IL specification

- Test channel IL is the IL between reference points in figure 110–4.
  - Frequency-dependent attenuator should be added such that test channel IL is within specified range.
- For test 1 (low loss): tables 110-5, 110-6, and 110-7 use the same values
  - Test channel max IL is the current value
  - Test channel min IL is the current value –0.5 dB
- For test 2 (high loss): values are different per table
  - Test channel min IL is the current value in each table
  - Max loss uses the current value in each table +0.5 dB

Proposed updated figures

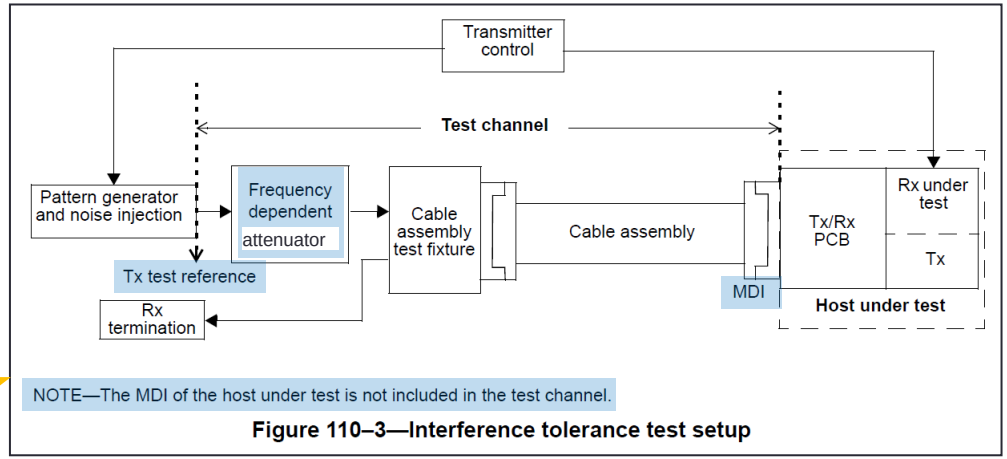

Figure 110–3—Interference tolerance test setup

Make sure these figures appear on the same page permanently.

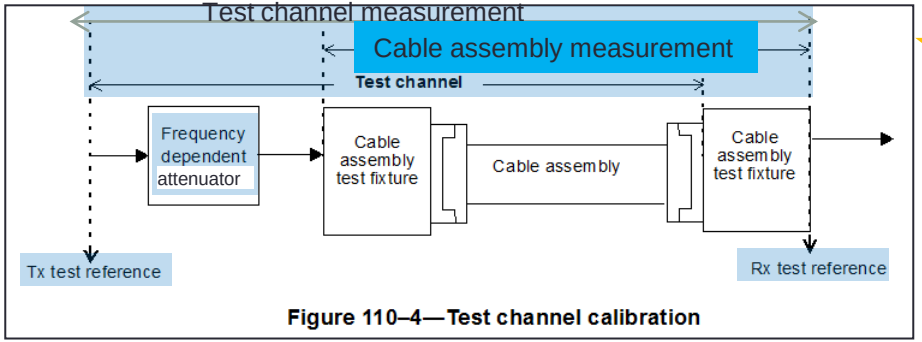

Figure 110–4—Test channel calibration

Test channel COM and calibration

- Clause 110 COM calculation:
  - Tx side:
    - Use measured Tx jitter values EBUJ, ERJ to set A_{DD} and σ_{RJ} (instead of values in 110.10.7), as done in 93.8.2.3
    - No package model; always use measured transition time for a Tx transition time filter (see later slide)
    - No PCB concatenated on Tx side: $z_{bp(tx)}$=0
      - Frequency-dependent attenuation is part of the measured test channel.
    - Injected noise: affects SNDR measured at the Tx test reference.
  - Rx side:
    - Reference host PCB concatenated: $z_{bp(rx)}$=151 mm (as done for qualifying cables)
    - Package model: in each test, calculate COM with both Test 1 and Test 2, choose the lower of the two (as done for qualifying cables)

    ➔DUT that is better than the reference host PCB and Rx package may get some margin for its own usage
- COM calibration (ITT only): change step c to

  Noise is injected (see 110.8.4.2.4) to set the value of SNDR, measured at the Tx test reference point using the procedure in 92.8.3.7, to the value of SNR_{TX} that results in the calculation of the required COM value for the test.

Test channel COM and calibration

- Clause 111 COM calculation:
  - Tx side:
    - Use measured Tx jitter values EBUJ, ERJ to set A_{DD} and σ_{RJ} (as done in 93.8.2.3).
    - No package model; always use measured transition time for a Tx transition time filter (see later slide)
  - Rx side:
    - Applied broad band noise: as in clause 93
    - Package model: in each test, calculate COM with both Test 1 and Test 2, choose the lower of the two (as done for qualifying channels)

    ➔DUT that is better than the reference package may get some margin for its own usage
- COM calibration (ITT only):
  - Set applied broad-band noise level to reach the target COM for the test.

Enable device or instrument as Tx

- In clause 110 interference tolerance test (ITT), remove requirements for applied RJ, SJ, EOJ in TX
  - Motivation: with packaged devices, control of high frequency SJ, RJ or EOJ might be insufficient.
  - Instead, jitter and transition time of the Tx are measured and used for COM calculation, as in clauses 93 & 111 (see earlier slide).
  - Enable tuning Tx equalization without the start-up protocol… ★ (not described explicitly in 111)
    - In the test procedure, change

      the device under test (DUT) configures the pattern generator equalizer, via transmitter control, to the coefficient settings it would select using the protocol described in 72.6.10 and the receiver is tuned using its optimization method.

    - To

      the device under test (DUT) configures the pattern generator transmit equalizer to the coefficient settings it would select using the start-up protocol described in 72.6.10 and the receiver is tuned using its optimization method. The coefficient settings may be communicated via the start-up protocol or by other means.
- In both 110 and 111…
  - Add a recommendation to use a transmitter with jitter close to Tx spec limits.
  - Specify that EOJ, ERJ and effective total uncorrelated jitter at Tx reference point must be below limit of Tx spec.

Enable device or instrument as Tx

- In clause 110 jitter tolerance test (JTT), specify SJ stress and no noise injection (as in 111).
  - JTT Setup and procedure refer to the ITT, so the above changes take effect too.
  - Change

    The test setup shown in Figure 110–3, or its equivalent, is used. The pattern generator meets the requirements of 110.8.4.2.4 except that no broadband noise is injected during the test, and the jitter is set to the frequency and peak-to-peak amplitude values specified in Table 110–8 instead. The test procedure is the same as the one described in 110.8.4.2.5.
  - To

    Receiver jitter tolerance is verified for each pair of jitter frequency and peak-to-peak amplitude values listed in Table 110–8. The test setup and procedure of 110.8.4.2 are used, with the exception that no noise is injected (COM calibration, as in step c in 110.8.4.2.3, is not performed), and instead, the specified jitter frequency is applied to the transmitter and the jitter amplitude is adjusted to obtain the specified peak-to-peak jitter for that frequency at the Tx test reference.

Transition time filter

- Tx transition time is measured, and the result is used to calculate a filter to be used in COM instead of a Tx package.
  - This should always be done – regardless of the Tx implementation (packaged device or instrument).
- D3.0 refers to the Gaussian filter defined in 802.3bj:

$$H_t(f) = \exp\left(-(\pi f T_r/1.6832)^2\right) \qquad \text{(93A–46)}$$

- This filter creates a 20%-to-80% transition time that is different from the T_r parameter.
  - This is not what we intended!
- The equation requires a factor of 2 to get the correct transition time:

$$H_t(f) = \exp(-2(\pi f T_r/1.6832)^2)$$

Equation (92–22) should be corrected similarly, but this is left for maintenance

- To correct without affecting 802.3bj PHYs:
  - Change Equation 93A–46 to $H_t(f) = \exp\left(-\beta(\pi f T_r/1.6832)^2\right)$ where β=1 unless stated otherwise. (➔no effect on clauses 92, 93)
  - In clause 110, refer to Equation 93A–46 instead of 92-22 and set β=2. (➔correct transition time)
  - In clause 111, refer to Equation 93A–46, and set β=2
    - and $T_r = 1.09 \times T_{rm} - 4.32$, where T_{rm} is the measured transition time at TP0a. (➔correct transition time and account for TP0-TP0a effect)

T_r is in ps

Transition time measurement ★

- Transition time depends on equalization setting. It is not specified which equalization setting should be used when measuring it.
- Since the transition time filter represents the transmitter bandwidth, and in view of the measurement procedure in 86A.5.3.3:
  - T_r is measured with the transmit equalizer turned off (coefficients set to the preset values, see 72.6.10.2.3.1) using the method in 86A.5.3.3.

BACKUP

Material presented in consensus building group

Consensus building summary slide

- In ITT, remove requirements for applied RJ, SJ, EOJ in TX.
  - Add a recommendation to use a transmitter with jitter close to TX spec limits.
  - Measured TX device ERJ, EBUJ and T_r to be used for COM calculation (as in clauses 93, 111).
  - EOJ at TX reference point must be below limit of TX
- In JTT, remove EOJ.
- To enable using test equipment
  - Add in both JTT and ITT: “The receiver may communicate through its associated transmitter, using the training protocol, or by other means”.
- Specify test channel construction
  1. Cable assembly
     - Compliant CA with fitted IL @12.89 GHz no lower than maximum allowed - 2 dB, e.g. 13.5 dB for CA-N. Normative
  2. Channel loss as specified in 110-5,6,7 is the loss between reference points
     - Including ““Additive host board loss” that should be added to a CA to reach this loss.
     - Minimum loss (high loss test) and max loss (low loss test) as in the tables. Maximum loss (high loss test) is table value + 0.5 dB. min loss (low loss test) is table value – 0.5 dB.
  3. “Additive host board loss”
     - Rename to “Frequency-dependent attenuation”.
     - Informative NOTE: ~~“approximate IL = x dB@12.89 GHz.~~ The frequency-dependent attenuation represents the host channel and may be implemented with PCB traces and test cables~~”. x=7 dB? 5.5 dB? See comment i-74.~~ (look for text in 83A)
     - PGC should be renamed to “Tx test reference”
     - Noise is added before and measured at the Tx test reference
       - Noise combiner (pickoff tee etc.) effects, such as flat loss or RL, are part of the transmitter
- Specify COM calculation
  1. Board parameters for COM: z_bp_tx=0 mm, z_bp_rx=151 mm
  2. No package on TX side, for either PG or device; use measured transition time for a TX filter, per corrected Gaussian equation (93A–46) For Clause 111: use modified T_r.
  3. Use measured jitter values to derive A_DD and sigma_RJ
  4. RX package length to assume for COM calculation – use the case that yields the lower COM (as done for qualifying cables)
- Transition time filter
  - Add missing factor of 2 in filter equation
  - Replace reference to 92-22 with the corrected 93A-46.