Creating a numeric result for Rx interference tolerance

Comment #98

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Noise calibration in Rx ITOL test

d) EOJ_{03}, $J3u_{03}$, and J_{RMS03} without noise injection (see 179.9.5.3.4) are measured at the Tx test reference and comply with the specification in Table 179–7. In the calculation of COM, A_{DD}, and σ_{RJ} are calculated from the measured values of $J3u_{03}$ and J_{RMS03} using Equation (179–11) and Equation (179–12), replacing the values in Table 179–17. It is recommended to adjust the pattern generator jitter such that J3u and J_{RMS} are as close as practical to their limits in Table 179–7.

e) In the calculation of COM, SNR_{TX} is set to the SNDR value with N_p=58 measured at the Tx test reference with pattern generator noise disabled.

f) For the CTLE and FFE settings used in the calculation of COM in items a) to e), find the value of σ_{TX} required to achieve the COM value specified in Table 179–11. From σ_{TX}, determine the value of σ_{ne} using Equation (179–13).

g) From σ_{ne}, the voltage transfer function $H_{21}^{(0)}(f)$ of the test channel, the transfer function $H_{ctf}(f)$ of the CTLE used in COM, and $H_{hp}(f)$ defined in Equation (179–15), find σ_{bn}, using Equation (179–14). From σ_{bn} and $H_{hp}(f)$ find σ_{hp} using Equation (179–16).

h) Set the RMS voltage of the noise added to the signal before the Tx test reference to σ_{hp}.

$$\sigma_{TX}^2 = [h^{(0)}(t_s)]^2 10^{-SNR_{TX}/10} + \sigma_{ne}^2 \quad (179\text{–}13)$$

$$\sigma_{ne}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \int_0^{f_b/2} \left|H_{hp}(f)H_{21}^{(0)}(f)H_r(f)H_{ctf}(f)\right|^2 df \quad (179\text{–}14)$$

$$H_{hp}(f) = \frac{j\frac{f}{f_{hp}}}{1 + j\frac{f}{f_{hp}}} \quad (179\text{–}15)$$

$$\sigma_{hp}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \left(\int_0^{f_b/2} \left|H_{hp}(f)\right|^2 df \right) \approx 0.6954\sigma_{bn}^2 \quad (179\text{–}16)$$

where

σ_{TX}	is the RMS transmitter noise
SNR_{TX}	is the transmitter signal-to-noise ratio
$H_{hp}(f)$	is the high-pass spectral shaping of the noise
f_{hp}	is the 3 dB cutoff frequency of the high-pass spectral shaping filter with a value of 6 GHz
σ_{bn}	is the RMS broadband noise amplitude
σ_{ne}	is the RMS filtered noise amplitude
σ_{hp}	is the RMS noise amplitude added at the transmitter test reference
$h^{(0)}$	is defined in 93A.1.5
$H_{21}^{(0)}(f)$	is defined in 93A.1.3
$H_r(f)$	is defined in 93A.1.4.1
$H_{ctf}(f)$	is defined in 93A.1.4.3

- The goal of steps f-h is to calculate the RMS level of broadband noise σ_{bn} that would create…
  - σ_{hp} after high-pass filtering
  - σ_{ne} after additional channel+Rx filtering
  - And σ_{TX} (after adding the noise corresponding to SNR_{TX}) that would bring the test channel + Tx to COM=3 dB
- … then, inject broadband noise with the resulting σ_{bn} at the pattern generator
- When the test is run, the result is pass/fail (based on the block error ratio requirement).

Concerns

- The procedure described above is quite complicated and non-intuitive
  - Essentially “going backward” from target COM to injected noise level
- If the test passes, it is a binary result
  - It does not indicate the margin, which is important in practice
  - Compare with optical receiver sensitivity tests, which have a numeric result (in dB)
- Depending on the test setup, it may be impossible to get COM to 3 dB
  - COM can be <3 dB before any noise/jitter injection
  - A receiver can have low enough block error rate even under these conditions, and thus demonstrate that it is better than the minimum requirements
  - This kind of test may be beneficial, but the current description makes it invalid

Alternative

- An equivalent process can be described by “going forward”
  - inject some initial broadband noise σ_{bn}
  - measure the RMS noise σ_{hp}
  - calculate COM with σ_{hp} (existing equations)
  - Tune σ_{bn} to obtain a target COM
- However, the test can be performed with any noise level…
  - Every value of σ_{bn} yields a COM value (higher σ_{bn} → lower COM)
  - The minimum COM at which the test passes can be the numeric “tolerance” result
  - Similar to receiver sensitivity
  - The specification would then be “interference tolerance COM <= 3 dB”

Proposed changes in Clause 179

(to be implemented with consideration of other comments and editorial license)

Keep 179.9.5.3.1, 179.9.5.3.2, and 179.9.5.3.4 unchanged.

In 179.9.5.3.3 (Test channel calibration), keep only text until list item e) and equations (179–11) through (179–15).

Change 179.9.5.3.5 (Test procedure) as follows:

The receiver interference tolerance COM is defined as the COM value calculated for the test channel with the transmitter parameters calculated from σ_{bn} (as defined in this subclause) and the pattern generator output measurements using equations (179–11) through (179–15).

During the test, the transmitters in the device under test (DUT) transmit the same pattern type specified for the test at “preset 1” state (maximum swing and no equalization).

Broadband noise with RMS value σ_{bn}, filtered by a high-pass filter defined by Equation (179-15), is injected at the test pattern generator (see 179.9.5.3.4). The noise spectral density meets equations (179–17) through (179–19). The value of σ_{bn} can be increased as long as the measured block error ratio, as defined in 174A.6 with $\text{BER}_{\text{Added}}$ specified in 179.2, does not exceed the maximum specified in Table 179–11.

The DUT may be tuned, including configuration of the pattern generator transmit equalizer, separately for different values of σ_{bn}. For this tuning, the DUT utilizes the ILT function (see 179.8.9) to communicate with the pattern generator, or configures the pattern generator in an equivalent way.

After the receiver indicates that it has completed the tuning, the pattern generator is set to generate the PRBS31Q pattern with or without precoding, as selected by the DUT. The block error ratio is then measured for a period long enough to enable verification of the requirement in Table 179–11 with sufficient confidence.

Changes to tables

Table 179–10—Summary of receiver specifications at TP3

Parameter	Subclause reference	Value	Units
Signaling rate (range)	179.9.5.1	106.25 ± 50 ppm	GBd
Amplitude tolerance (min)	179.9.5.2	1.2	V
Interference tolerance COM (max)	179.9.5.3	3	dB
<…>	<…>	<…>	<…>

Table 179–11—Interference tolerance test parameters

Parameter	Test 1 (low loss)		Test 2 (high loss)		Units
	Min	**Max**	**Min**	**Max**	
Block error ratio [a]		1.45×10^{-11}		1.45×10^{-11}	—
Test channel insertion loss at 53.125 GHz [b]	<…>	<…>	<…>	<…>	dB
Cable assembly insertion loss at 53.125 GHz	<…>	<…>	<…>	<…>	dB
~~**COM**~~					~~dB~~

Other clauses and annexes

- Interference tolerance in Annex 176D is based on the same test as that of Clause 179. It should be changed similarly.
- Interference tolerance in Clause 178 and Annex 176C is based on a procedure in Annex 93C…
  - But with a long list of “considerations” (some of which are practically exceptions or replacements).
  - The intent is conceptually similar to that of Clause 179, except that noise is added near the receiver instead of at the test pattern generator.
  - Achieving a similar effect (numeric result) will be easier if the procedure is written cleanly in 802.3dj, instead of referring to Annex 93C.
  - We should decide whether to do it based on this presentation (with wide editorial license) or wait for a separate detailed proposal.

That’s all

Questions?