Interpretation of noise injection in RIT test calibration (162.9.4.3.3)

(supplement to comment I-54)

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What's it about

162.9.4.3.3 Test channel calibration

The scattering parameters of the test channel are measured at the test references as illustrated in Figure 110–3b using the cable assembly test fixtures specified in Annex 162B.1.

The insertion loss at 26.56 GHz of the signal path between the test references in Figure 110–3b is within the limits in Table 162–15.

The COM is calculated using the method and parameters of 162.11.7 with the following considerations:

a) The channel signal path is $SCHS_p$ = cascade($S^{(CTSP)}$, $S^{(HOSPR)}$), where cascade() is defined in 93A.1.2.1, $S^{(HOSPR)}$ is defined in 162.11.7.1.1, and $S^{(CTSP)}$ is the measured channel between the test references in Figure 110–3b.

b) COM is calculated using both Test 1 and Test 2 device package model transmission line lengths listed in Table 162–19 on the receiver side. The value of COM is taken as the lower of the two calculated values.

c) The augmented signal path in 93A.1.2 is replaced by S_p determined from Equation (162–6) (effectively omitting the transmitter device package model $S^{(tp)}$). The filtered voltage transfer function $H^{(k)}(f)$ calculated in Equation (93A–19) uses T_r equal to the transition time at the Tx test reference. T_r is measured using the method in 120E.3.1.5 with the transmit equalizer turned off (i.e., coefficients set to the preset 1 values, see 162.9.3.1.3) with an exception that the waveform is observed through a fourth-order Bessel-Thomson low-pass response with a 3 dB bandwidth of 40 GHz.

d) Even-odd jitter, J3u, and J_{RMS} without noise injection (see 162.9.4.3.4) are measured at the Tx test reference and comply with the specification in Table 162–10. In the calculation of COM, A_{DD}, and σ_{RJ} are calculated from the measured values of J3u and J_{RMS} using Equation (162–7) and Equation (162–8), replacing the values in Table 162–19. 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 162–10.

e) COM is used to calibrate the amplitude of the noise added to the signal before the Tx test reference using the definition of σ_{TX} given by Equation (162–9), Equation (162–10) and Equation (162–11) with f_{hp} set to 6 GHz. In Equation (162–9), SNR_{TX} is set to the SNDR value measured at the Tx test reference using the procedure in 120D.3.1 with the exception that the linear fit in 120D.3.1.3 is performed with a pulse length (N_p) of 29 UI and with pattern generator noise disabled. Determine the value of σ_{bn} required to achieve COM value specified in Table 162–15. The amplitude of the noise added to the signal before the Tx test reference is σ_{hp} which is derived from the RMS broadband noise amplitude, σ_{bn}, as defined in Equation (162–12).

Item e is the calibration of the Tx injected noise to reach the target COM.
The subsequent page contains the equations.

Cl **162** *SC* **162.9.4.3.3** *P* **175** *L* **39** # I-54

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Comment Type **TR** *Comment Status* **X**

Item e in the list is very difficult to understand, and the referenced equations have some parameters defined in Annex 93A which may be unclear. ~~Also, the value of f_hp in equation 162-11 is not provided anywhere~~.

The phrasing should be improved to enable implementing this procedure.

SuggestedRemedy

A presentation proposing a rewrite is planned.

Proposed Response *Response Status* **O**

Existing text and equations

e) COM is used to calibrate the amplitude of the noise added to the signal before the Tx test reference using the definition of σ_{TX} given by Equation (162–9), Equation (162–10) and Equation (162–11) with f_{hp} set to 6 GHz. In Equation (162–9), SNR_{TX} is set to the SNDR value measured at the Tx test reference using the procedure in 120D.3.1 with the exception that the linear fit in 120D.3.1.3 is performed with a pulse length (N_p) of 29 UI and with pattern generator noise disabled. Determine the value of σ_{bn} required to achieve COM value specified in Table 162–15. The amplitude of the noise added to the signal before the Tx test reference is σ_{hp} which is derived from the RMS broadband noise amplitude, σ_{bn}, as defined in Equation (162–12).

$$\sigma_{TX}^2 = [h^{(0)}(t_s)]^2 10^{-SNR_{TX}/10} + \sigma_{ne}^2 \quad (162\text{–}9)$$

$$\sigma_{ne}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \int_0^{f_b/2} \left|H_{hp}(f) H_{21}^{(0)}(f) H_r(f) H_{ctf}(f)\right|^2 df \quad (162\text{–}10)$$

$$H_{hp}(f) = \frac{j\frac{f}{f_{hp}}}{1 + j\frac{f}{f_{hp}}} \quad (162\text{–}11)$$

$$\sigma_{hp}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \left(\int_0^{f_b/2} |H_{hp}(f)|^2 df \right) \approx 0.6954\sigma_{bn}^2 \quad (162\text{–}12)$$

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
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

How are these obtained?

I'm confused!

What is the expected procedure?

1. Calculate COM for the channel $H_{21}^{(0)}$ defined in items a-c, using the method parameters of 162.11.7, and obtain the chosen CTLE transfer function H_{ctf}
2. Find the value of σ_{TX} that would result in the target COM value in Table 162–15 (3 dB): "COM is used to calibrate the amplitude of the noise added to the signal before the Tx test reference using the definition of σ_{TX}"
3. Measure SNR_{TX} of the pattern generator: "SNR_{TX} is set to the SNDR value measured at the Tx test reference using the procedure in 120D.3.1 with the exception that the linear fit in 120D.3.1.3 is per-formed with a pulse length (Np) of 29 UI and with pattern generator noise disabled"
4. From σ_{TX} (#2) and SNR_{TX} (#3), calculate σ_{ne} using equation (162-9)
5. From σ_{ne} (#4), $H_{21}^{(0)}$ (the test channel), H_{ctf} (#1), and the definition of $H_{hp}(f)$ in equation (162-11), find σ_{bn} using equation (162-10)
6. From σ_{bn} (#5) and $H_{hp}(f)$, find σ_{hp} using equation (162-12)
7. The resulting σ_{hp} (#6) is "The ~~amplitude~~ RMS of the noise added to the signal before the Tx test reference"

a) The channel signal path is $SCHS_p$ = cascade($S^{(CTSP)}$, $S^{(HOSPR)}$), where cascade() is defined in 93A.1.2.1, $S^{(HOSPR)}$ is defined in 162.11.7.1.1, and $S^{(CTSP)}$ is the measured channel between the test references in Figure 110–3b.

b) COM is calculated using both Test 1 and Test 2 device package model transmission line lengths listed in Table 162–19 on the receiver side. The value of COM is taken as the lower of the two calculated values.

c) The augmented signal path in 93A.1.2 is replaced by S_p determined from Equation (162–6) (effectively omitting the transmitter device package model $S^{(tp)}$). The filtered voltage transfer function $H^{(k)}(f)$ calculated in Equation (93A–19) uses T_r equal to the transition time at the Tx test reference. T_r is measured using the method in 120E.3.1.5 with the transmit equalizer turned off (i.e., coefficients set to the preset 1 values, see 162.9.3.1.3) with an exception that the waveform is observed through a fourth-order Bessel-Thomson low-pass response with a 3 dB bandwidth of 40 GHz.

$$\sigma_{TX}^2 = [h^{(0)}(t_s)]^2 10^{-SNR_{TX}/10} + \sigma_{ne}^2 \qquad (162\text{–}9)$$

$$\sigma_{ne}^2 = \frac{\sigma_{bn}^2}{(f_b/2)} \int_0^{f_b/2} \left|H_{hp}(f)H_{21}^{(0)}(f)H_r(f)H_{ctf}(f)\right|^2 df \qquad (162\text{–}10)$$

$$H_{hp}(f) = \frac{j\frac{f}{f_{hp}}}{1 + j\frac{f}{f_{hp}}} \qquad (162\text{–}11)$$

(Where f_{hp}=6 GHz)

$$\sigma_{hp}^2 = \frac{\sigma_{bn}^2}{(f_b/2)}\left(\int_0^{f_b/2} \left|H_{hp}(f)\right|^2 df\right) \approx 0.6954\sigma_{bn}^2 \qquad (162\text{–}12)$$

Proposal for alternative text (replacing item e)

e) In the calculation of COM, SNR_{TX} is set to the SNDR value measured at the Tx test reference using the procedure in 120D.3.1 with the exception that the linear fit in 120D.3.1.3 is performed with a pulse length (N_p) of 29 UI and with pattern generator noise disabled.

f) For the CTLE and FFE settings used in the calculation of COM in items a-e, find the value of σ_{TX} required to achieve the COM value specified in Table 162–15. From σ_{TX}, determine the value of σ_{ne} using equation (162-9).

g) From σ_{ne}, the voltage transfer function $H_{21}^{(0)}$ of the test channel, the transfer function H_{ctf} of the CTLE used in COM, and $H_{hp}(f)$ defined in equation (162-11), find σ_{bn} using equation (162-10). From σ_{bn} and $H_{hp}(f)$, find σ_{hp} using equation (162-12).

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

Additionally

- Provide the value of f_{hp} (=6 GHz) below equation (162-11) instead of in the text, or use the number and remove the parameter