Correction in Calculation of scale factor of the additional receiver noise, g_an, in COM Matlab Code

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Introduction

- Section “178A.1.10.1. Additional receiver noise” in D1.5 defines the method that increases receiver noise before MLSD COM calculation to mimic the implementation penalty
- A recent review of the section of the COM code that implements this section revealed “g_an”, the scale factor for the added noise, is not correctly calculated in function “MLSE_U1_c_178A”
- This contribution summarizes how this scale factor was intended to be calculated based on section “178A.1.10.1 Additional receiver noise” of D1.5 and how to fix the code
- It also suggests considering a comment against the draft in the next cycle for clarification to prevent future confusions

Quick Review of the “Additional receiver noise” Method

- The idea is to add a new noise term by adding a scaled version of the receiver noise PSD (eta_0 noise) to the overall noise PSD prior to MLSD, as described by Equation (178A-42):

$$S_{an}(\theta) = g_{an} S_{rn}(\theta) \left| H_{rxffe}(\theta) \right|^2 \qquad (178A\text{–}42)$$

PSD of the additional noise

Scaling factor

PSD of the receiver noise at the Rx FFE input

PSD of the receiver noise at the Rx FFE output

- This additional noise is added to the Gaussian portion of the total noise and the result replaces σ_G as described by Equation (178A-43) and the sentence above it:

replacing σ_G with σ_{an} where σ_{an} is defined by Equation (178A–43).

$$\sigma_{an}^2 = \sigma_G^2 + f_b \int_{-\pi}^{\pi} S_{an}(\theta) d\theta \qquad (178A\text{–}43)$$

Power of the Gaussian noise including the additional noise

Power of the Gaussian noise excluding the additional noise

Power of the additional noise

- Apparently, the choice of parameter names has been confusing as subscript $\cdots_{an}$ represents additional noise in $S_{an}(\theta)$, but Gaussian part of noise that now includes additional noise in σ_{an}

Recommendation for a Later Action for Clarity

- This confusion appears to have caused an error in the Matlab COM code
- It is suggested to clarify this by a simple change in the draft:

replacing σ_G with σ_{an} where σ_{an} is defined by Equation (178A–43).

G_an G_an

$$\sigma_{an}^2 = \sigma_G^2 + f_b \int_{-\pi}^{\pi} S_{an}(\theta) d\theta \qquad (178A–43)$$

G_an

Keep σ_{an} reserved for this term

- A comment against D1.5 will be submitted for clarity

The Issues with Matlab Code

- g_{an} scales the noise PDF, PDF, by an increase target amount, $delta\_COM\_an$:

```
[p_an, P_an, ~] = scaleCDF( PDF,delta_COM_an,DERO, A_s );
```

- The difference between the scaled noise and the original noise yields σ of the additional receiver noise:

```
sigma_an_2_pdf=sum(p_an.y.*p_an.x.^2)-sum(PDF.y.*PDF.x.^2);
```

- Naturally, g_{an} should be the ratio between power of this additional noise and power of the receiver noise (eta_0):

```
g_an=(sigma_an_2_pdf-PSD_results.S_G_rms^2)/PSD_results.S_rn_rms^2;
```

- The extra term in the above line appears to be due to the confusion and should be removed
  - ❖ Note that $sigma\_an\_2\_pdf$ assumes Equation (178A-43), which includes the Gaussian noise part, whereas this is clearly not the case and $sigma\_an\_2\_pdf$ is already the difference

Test Case Verification

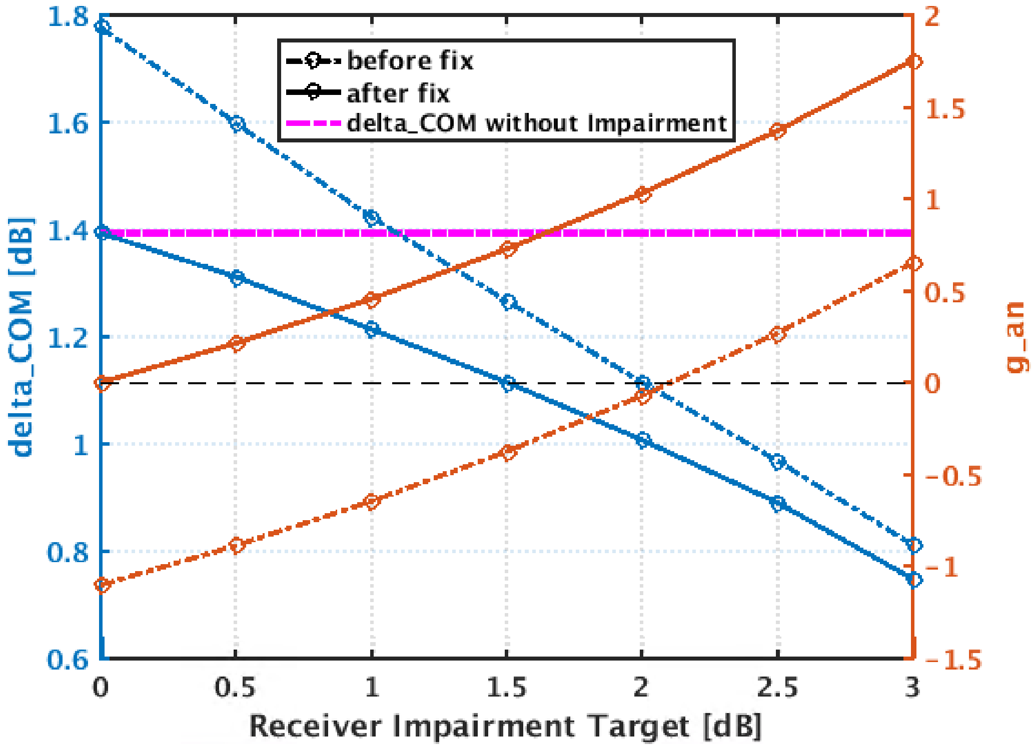
- This issue can result in a negative g_{an}, expected to be positive (see Line 20, page 784 of D1.5):

g_{an} is a scale factor for the added noise with a value greater than or equal to 0.

- Without a fix, g_{an} will become negative when $sigma\_an\_2\_pdf < PSD_{results}.S\_G\_rms$:

```
2152 -    g_an=(sigma_an_2_pdf-PSD_results.S_G_rms^2)/PSD_results.S_rn_rms^2;
```

- This will happen at a target $delta\_COM\_an$ level that corresponds to the above inequality
- This can be immediately seen if this target is set to 0, which forces $sigma\_an\_2\_pdf = 0$, whereas for a zero target $g_{an} = 0$ is expected
- Sample COM results of a test case confirm that:
  - ✗ Before fix, g_{an} becomes negative for scale target < ~2.1dB
  - ✓ After fix, g_{an} always stays positive and approaches 0 as scale target approaches 0
  - ✗ Before fix, delta_COM is an over-estimate and exceeds its maximum allowed level
  - ✓ After fix, delta_COM approaches its maximum allowed level as scale target approaches 0



Thank You ☺

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