

Correction in Implementation of Equation (178A-42) in D1.4 in the COM Matlab Code

COM Commit Request Number 4p8_1

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Introduction

- As explained in D1.4 section 178A.1.10.1, the receiver noise is increased before COM for the MLSD reference receiver is computed to account for implementation penalty
- Equation (178A-42) defines how PSD of this additional noise is calculated:

$$S_{an}(\theta) = g_{an} S_{rn}(\theta) |H_{rxffe}(\theta)|^2 \quad (178A-42)$$

- This is the same equation on slide 12 in healey_3dj_01_2409.pdf
- In this equation, $S_{rn}(\theta)$ is PSD of the noise due to the receiver input noise (η_0) at the input of the RxFFE as explained in D1.4 section 178A.1.7.1 and defined by Equation (178A-16):

$$S_{rn}(\theta) = \frac{\eta_0}{2} \sum_{m \text{ integer}} \left| H_{rn} \left(\frac{\theta + 2\pi m}{2\pi T_b} \right) \right|^2 \quad (178A-16)$$

where $H_{rn}(f)$ is $H_r(f)H_{cfe}(f)$.

- Naturally, and correctly so, Equation (178A-42) reflects the noise amplification by RxFFE

The Issue

- Line 2173 of the COM Matlab code (version 480) in the MLSE_U1_c_178A function is the attempt to implement Equation (178A-42):

```
2173 - S_an=g_an*PSD_results.S_rn.*PSD_results.H_rxffe_2; % healey_3dj_01_2409 slide 12
2174 - S_ni=PSD_results.S_isi +PSD_results.S_n +S_an; % 178A-40, healey_3dj_01_2409 slide 15
```

- However, “PSD_results.S_rn”, which is calculated by the “get_PSDs” function, is already PSD after RxFFE (Line 2173 double counts RxFFE noise amplification of receiver input noise):

```
K>> OP.COMPUTE_COM
ans =
     1
```

→

→

```
4828
4829 ● %% compute S_rn ( eq 178A-15 d0.2 )
4830 - if ~OP.COMPUTE_COM
4831 -     S_RN_of_f=S_RN(fvec,G_DC,G_DC2,param);
4832 -     rxn_psd=[real(S_RN_of_f(1)), S_RN_of_f(2:end-1), real(S_RN_of_f(end)), conj(S_RN_of_f(end-1:-1:2))];
4833 -     rxn_psd=rxn_psd/1e9;% Units are VA2/Hz.
4834 -     rxn_rms = sqrt(sum(rxn_psd)* delta_f);
4835 -     S_rn = sum(reshape(rxn_psd, num_ui, M).');
4836 -     S_rn=S_rn(1:num_ui/2+1);
4837 -     S_rn= [real( S_rn(1)), S_rn(2:end-1), real( S_rn(end)), conj( S_rn(end-1:-1:2))];
4838 -     result.S_rn=S_rn;
4839 -     result.S_rn_rms = sqrt(sum(result.S_rn)* delta_f);
4840 - else
4841 -     result.S_rn=result.S_rn.*H_rxffe_2;
4842 -     result.S_rn_rms = sqrt(sum(result.S_rn)* delta_f);
4843 - end
```

Section from
“get_PSDs”
function

- This change is also consistent with “PSD_results.S_isi” and “PSD_results.S_n” used in the line 2174 (below the line in question), which also correctly assumes PSDs after RxFFE

Change

- Change line 2173 to remove multiplication by “PSD_results.H_rxffe_2”:

```
→ 2173 - S_an=g_an*PSD_results.S_rn; %.*PSD_results.H_rxffe_2; % healey_3dj_01_2409 slide 12  
2174 - S_ni=PSD_results.S_isi +PSD_results.S_n +S_an; % 178A-40, healey_3dj_01_2409 slide 15
```

Example Outputs

- For one example channel:

Before Change	After Change
<pre>CDF: [1x8573 double] PDF: [1x1 struct] DER_MLSE_trunc: 2.6802e-04 Q_budget_adj: 0 COM_from_matlab: -0.7485 DER_MLSE: 2.6802e-04 DER_DFE: 5.9072e-04 COM: -0.1852 delta_com: 0.5633 g_an: 0.6510</pre>	<pre>CDF: [1x8331 double] PDF: [1x1 struct] DER_MLSE_trunc: 1.8536e-04 Q_budget_adj: 0 COM_from_matlab: -0.7485 DER_MLSE: 1.8536e-04 DER_DFE: 5.9072e-04 COM: 0.0635 delta_com: 0.8120 g_an: 0.6510</pre>

- All the performance parameters after MLSE are affected by this error
- For this particular example, the double counting of the RxFFE noise enhancement had dropped delta_COM and COM (after MLSE) by 0.25dB

An Interesting Case

- Without the change, there may be cases that yield a negative delta_COM (due to excessive noise caused by double counting of RxFFE noise amplification) and wrongfully reduce COM
- Indeed, an example was observed:

Before Change	After Change
<pre>CDF: [1x29133 double] PDF: [1x1 struct] DER_MLSE_trunc: 1.7390e-04 Q_budget_adj: 0 COM_from_matlab: 0.5246 DER_MLSE: 1.7390e-04 DER_DFE: 3.9645e-05 COM: -0.3223 delta_com: 0 g_an: 8.1800</pre>	<pre>CDF: [1x26709 double] PDF: [1x1 struct] DER_MLSE_trunc: 8.2701e-06 Q_budget_adj: 0 COM_from_matlab: 0.5246 DER_MLSE: 8.2701e-06 DER_DFE: 3.9645e-05 COM: 1.2795 delta_com: 0.7549 g_an: 8.1800</pre>

Reduces COM

Increases COM

- Please see Commit Request Number 4p8_2 to address this issue

Thank You 😊

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