COM Commit Requests: 4p6_6 Align to D1.2 Annex 178A MLSD

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COM Ad Hoc October 29, 2024

Prior Commit Requests for COM 4.7

- [4p6_1] Change MLSE_U1_c_178A code module to align with shakiba_3dj_01_2407
  - Submitter: Rich Mellitz
- [4p6_2] Change MLSE_U1_c_178A code module to align with healey_3dj_01a_2407
  - Submitter: Rich Mellitz
- [4p6_3] Change read_ParamConfigFile code module to align clean up package syntax in configuration spreadsheet to no longer require dummy Zp and Zc entries
  - Submitter: Rich Mellitz
- [4p6_4] MLSE Sequence Truncation Feature (not implemented yet)
  - Update TO [4p6_3]
- [4p6_5] Quantization Noise Feature (not implemented yet)
- [4p6_6] Align to D1.2 Annex 178A MLSD

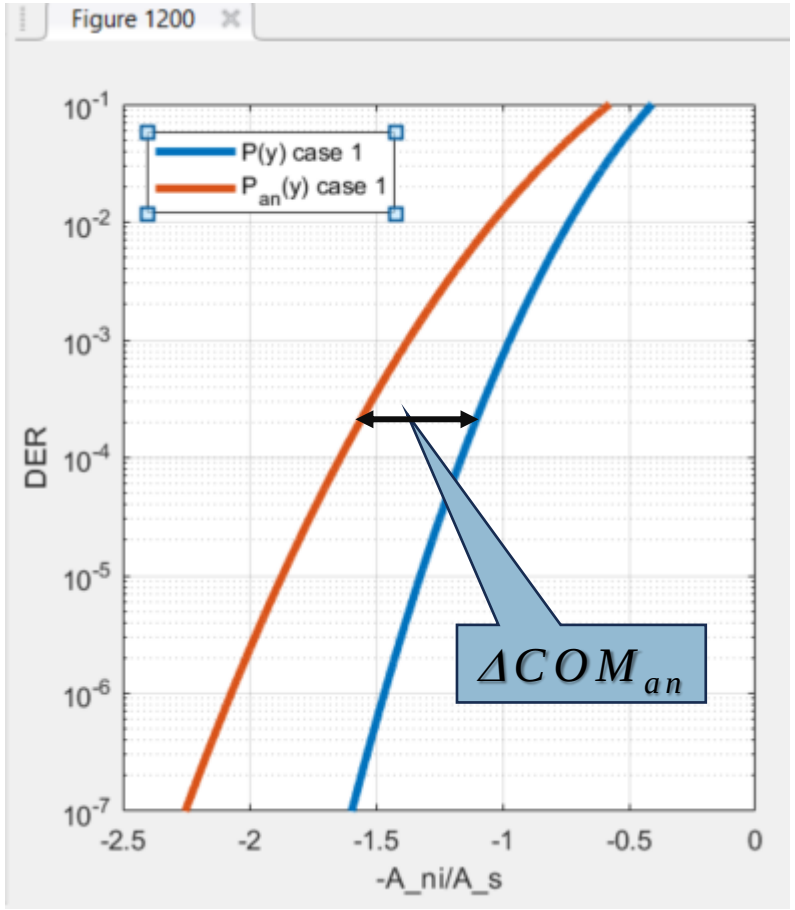
COM 4.7beta1

COM 4.7beta3

[4p6_6] Align to D1.2 Annex 178A MLSD

- No new functional COM configuration keywords
  - Allow MLSD (178A alignment) keyword to be used for the old MLSE keyword
- Remove eye diagram display if MLSD or MLSE is set
- Remove functions MLSE_U1_c, MLSE_U3, and WIENER_HOPF_MMSE (obsolete)
- Remove code for delta COM Q factor in [4p6_2]
- Add COM adjusted CDF and noise scaling in COM with MLSE pre D1.2 Annex 178A aligned with healey_3dj_01_2409
- COM sub functions functions
  - Update main COM script com_ieee8023_93a_470beta3, MLSE_FOM, and MLSE_U1_c_178A for parameter passing
  - Add new function scaleCDF
  - Update MLSE_U1_c_178Ato align with D1.2
  - Update get_PSDs to align with D1.2
  - adjust “read_ParamConfigFile” for MLSD command
  - Add to comments to file “zzz_list_of_changes.m”

Implement D1.2 179A.1.11.1 updates



- CDF, Pan, is defined in 178A.1.11.1

"The value of *gan* that is used to calculate COM for the MLSD reference receiver is the value that makes the quantity $20*log_{10}[P^{-1}{}_{an}(DER_0)/P^{-1}(DER_0)]$ equal to the specified value of ΔCOM_{an} . If the value of ΔCOM_{an} is not specified, it defaults to the minimum COM limit defined by the clause or annex that specifies the use of this calculation. "

- We can take advantage of the PDF and CDF structures in to simple P(y) to Pan(Y)
- COM pdf structure, p has x (voltage) bins vs y (probability) fields which make it easy to scale at the anchor points define at DER_0.
  - A function called scaleCDF was added to do this
- Another feature of the PDF/CDF structure is that the variance may be calculated as follows.
  - $\sigma^2 = \sum p.x^2 * p.y \;\; for\ all\ bins$

Compute σ_{an} and g_n

- $\sigma_{an}{}^2 = \sum p_{an}.x^2 * pan.y \;\; for\ all\ bins$
- Re-arrange eq 179A-39 and 179A-39

  $\sigma_{an}{}^2 = \sigma_G{}^2 + fb \int_{-\pi}^{\pi} g_n S_{rn}(\theta)\, |Hrxff_e(\theta)|^2 d\theta$
- $g_n = \sigma_{an}{}^2 - \sigma_G{}^2 / (f_b \int_{-\pi}^{\pi} S_{rn}(\theta)\, |Hr_{xffe}(\theta)|^2 d\theta)$
  - Use definitions from function get_PSDs for σ_G, $S_{rn}(\theta)$,and $Hr_{xffe}(\theta)$

Recompute DER_{MLSD} Eq 178A–37

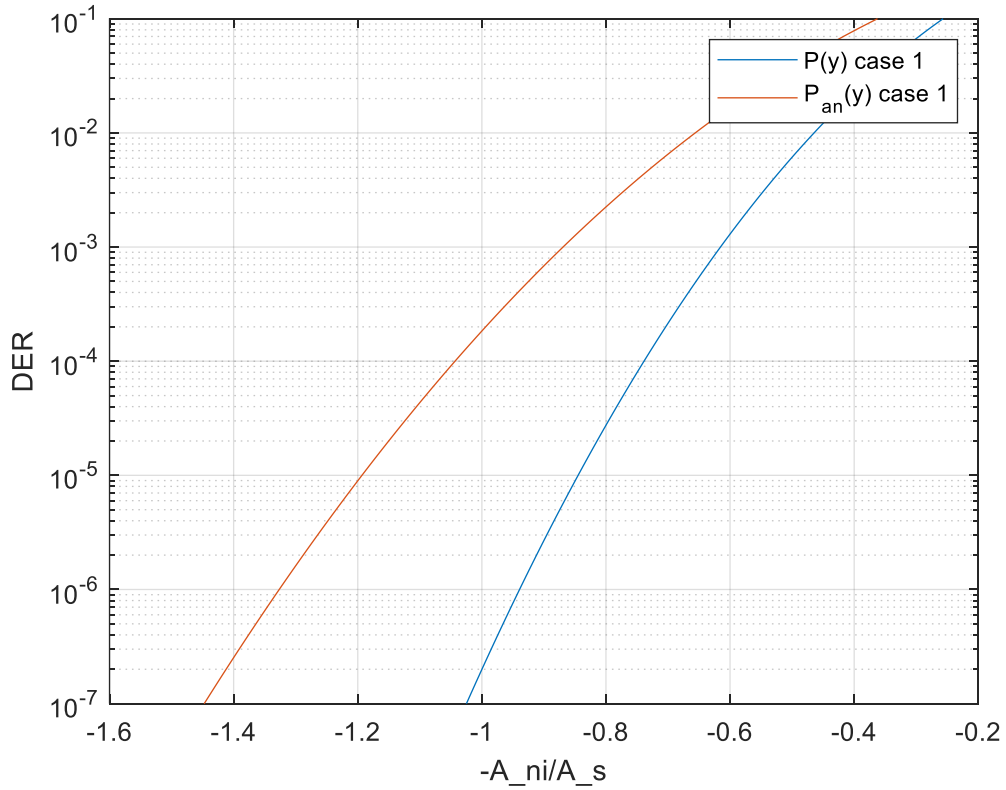
- For j = 1 to infinity
  - Or limit j to truncation (shakiba_3dj_01_2407)
- For Eq 178A–37, recompute $A_{ni}(n)$ and V_j

Recompute COM

- Implement equation 178a-35 using DER_{MLSD} and CDF P_{an}.
- $COM = COM_{DFE} + 20log_{10}\left({-P_{an}^{-1}(DER_{MLSD})}/{A_s}\right)$
- Report delta COM as $20log_{10}\left({-P_{an}^{-1}(DER_{MLSD})}/{A_s}\right)$

Added temporary plot if MLSD is used

- Visualize new CDFs for MLSD



Summary

- Added functionality to MLSD to D1.2
- Remove some obsolete MLSE functions
- Draft 4.7 is planned to clean up some reporting and include other submit requests
  - Recommend COM output consensus meeting

Thank You!

Backup details

Function scaleCDF added

```
function [pdf_out, cdf_out, scale_factor] = scaleCDF(pdf,delta_com,DER0,A_s)
% scale CDF at DER0 to delta_com
pdf_out=pdf;
P=cumsum(pdf.y);
ider0=find(P>=DER0,1,'first');
anias=pdf.x(ider0)/A_s; % ani/as
new_db = 20*log10(-1/anias)-delta_com;
new_value = -1*1/10^(new_db/20);
scale_factor=1/10^(-delta_com/20);
pdf_out=scalePDF(pdf,scale_factor);
cdf_out=cumsum(pdf_out.y);
```

For Equation 178A-78: changes to pass blim into MLSE_U1_c_178A

com_ieee8023_93a_470beta3.m

```
564                 COM=20*log10(A_s/A_ni);
565                 min_COM = min(min_COM, COM);
566                 min_VEO_mV = min(min_VEO_mV,VEO_mV);
567                 max_VEC_dB = max(max_VEC_dB, VEC_dB);
568             end
569             MLSE_results=struct;
570         else
571             % [MLSE_results] =  MLSE_U1_c_178A(param,fom_result.DFE_taps(1),A_s,A_ni,PDF,CDF,PSD_results);
572             [MLSE_results] =  MLSE_U1_c_178A(param,fom_result.MMSE_results.blim,A_s,A_ni,PDF,CDF,PSD_results);% al
573              if param.T_O ~=0
```

com_ieee8023_93a_470beta1.m

```
565                 COM=20*log10(A_s/A_ni);
566                 min_COM = min(min_COM, COM);
567                 min_VEO_mV = min(min_VEO_mV,VEO_mV);
568                 max_VEC_dB = max(max_VEC_dB, VEC_dB);
569             end
570             MLSE_results=struct;
571         else
572             [MLSE_results] =  MLSE_U1_c_178A(param,fom_result.DFE_taps(1),A_s,A_ni,PDF,CDF,PSD_results)
573              if param.T_O ~=0
```

```
2340  end
2341  [sigma_e,FOM,w,idx,Nw,blim] = MMSE_FOM(param,H,Nb,Rnn,dw,d,wmax,wmin,bmin,bmax,sigma_X2,idx); % bring out blim for
2342  MMSE_results.sigma_e=sigma_e; %
2343  MMSE_results.FOM=FOM;
2344  Craw=w/w(dw+1); % returned Rx FFE taps
2345  % re-align Cmod to floating tap locations
2346  if param.N_bg ~= 0
2347      C=Craw;
2348      C(Nfix+1:Nmax+param.ffe_pre_tap_len+1)=0;% from Tobey (Pei-Rong Li 02/28/2024)
2349      C(idx+param.RxFFE_cmx+1 )=Craw(Nfix+(1:Nfloating_taps));
2350  else
2351      C=Craw;
2352  end
2353  MMSE_results.floating_tap_locations=idx + param.RxFFE_cmx+1;
2354  MMSE_results.C=C;
2355  MMSE_results.blim=blim; % added blim passed out for MLSD for 178A-39
2356  MMSE_results.Nw=Nw;
2357
2358
2359
2360
2361
2362  function [sigma_e,FOM,w,idx,Nw,blim] = MMSE_FOM(param,H,Nb,Rnn,dw,d,wmax,wmin,bmin,bmax,sigma_X2,idx)
2363  % added blim passed out for MLSD
```

```
2594  end
2595  [sigma_e,FOM,w,idx] = MMSE_FOM(param,H,Nb,Rnn,dw,d,wmax,wmin,bmin,bmax,sigma_X2,idx);
2596  MMSE_results.sigma_e=sigma_e; %
2597  MMSE_results.FOM=FOM;
2598  Craw=w/w(dw+1); % returned Rx FFE taps
2599  % re-align Cmod to floating tap locations
2600  if param.N_bg ~= 0
2601      C=Craw;
2602      C(Nfix+1:Nmax+param.ffe_pre_tap_len+1)=0;% from Tobey (Pei-Rong Li 02/28/2024)
2603      C(idx+param.RxFFE_cmx+1 )=Craw(Nfix+(1:Nfloating_taps));
2604  else
2605      C=Craw;
2606  end
2607  MMSE_results.floating_tap_locations=idx + param.RxFFE_cmx+1;
2608  MMSE_results.C=C;
2609
2610
2611
2612
2613  function [sigma_e,FOM,w,idx,Nw] = MMSE_FOM(param,H,Nb,Rnn,dw,d,wmax,wmin,bmin,bmax,sigma_X2,idx)
```

CDF $P_{an}(y)$ computed

- Give CDP P computed from PDF p, PSD having p.y and p.x, variances are directly computed.
- The variance difference is used to compute g_{an} in equation 178A-39 and the variance, s^2_{an} , equation 178A-40

```
function [MLSE_results] = MLSE_U1_c_178A(param,b,A_s,A_ni,PDF,CDF,PSD_results)
if 1
    num_ui=param.num_ui_RXFF_noise;
    M=param.samples_per_ui;
    L=param.levels;
    sigma_X2=(L^2-1)/(3*(L-1)^2);
    f_b=param.fb;
    DER0=param.specBER; % align terminology
    delta_COM_an=param.pass_threshold; % align terminology
end
% new function to scale CDF at specified DER; healey_3dj_01_2409 slide 8, 12, and 13
% directly compute p_an (PDF) and P_an (CDF);
[p_an, P_an, ~] = scaleCDF( PDF,delta_COM_an,DER0, A_s );
sigma_an_2_pdf=sum(p_an.y.*p_an.x.^2)-sum(PDF.y.*PDF.x.^2);
sigma_G_2=PSD_results.S_G_rms^2;
g_an=(sigma_an_2_pdf-PSD_results.S_G_rms^2)/PSD_results.S_rn_rms^2;
```

```
2235  function [MLSE_results] = MLSE_U1_c_178A(param,b,A_s,A_ni,PDF,CDF,PSD_results)
2236  if 1
2237      num_ui=param.num_ui_RXFF_noise;
2238      M=param.samples_per_ui;
2239      L=param.levels;
2240      sigma_X2=(L^2-1)/(3*(L-1)^2);
2241      f_b=param.fb;

2242  end
```

Equation 178A-37 adjusted to stay with P_{an} and delta COM compute as in equation 178A-36

```
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
2175  R_ni=ifft(S_ni)*f_b;
2176  p_scaled_by_b=scalePDF(p_an,b(1));
2177  p_j=conv_fct(p_an,p_scaled_by_b);
2178  p_scaled_by_1mb=scalePDF(p_an,1-b(1));
2179  %% %% shakiba_3dj_01_2407 (to add MLSE sequence truncation penalty)
2180  p_trunc = p_an;
```

```
2245  S_ni=PSD_results.Sn_rho;
2246  R_ni=ifft(S_ni)*f_b;
2247  p_scaled_by_b=scalePDF(PDF,b(1));
2248  p_j=conv_fct(PDF,p_scaled_by_b);
2249  p_scaled_by_1mb=scalePDF(PDF,1-b(1));
2250  %% %% shakiba_3dj_01_2407 (to add MLSE sequence truncation penalty)
2251  p_trunc = PDF;
```

com_ieee8023_93a_470beta3.m

```
2218  % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE      ,p_an,P_an )  )- param.Q ;% shakiba_3dj_01_2405
2219  delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE_trunc,p_an,P_an )  )- Q_budget_adj ;% shakiba_3dj_01_2405
2220  %% shakiba_3dj_01_2407
2221  % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,p_an,CDF )  )- Q ;% (178A-36)
2222  new_com=COM_from_matlab+delta_com;
2223  if(delta_com<0)
```

com_ieee8023_93a_470beta1.m

```
2288  % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE      ,PDF,CDF )  )- param.Q ;% shakiba_3dj_01_2405
2289  delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE_trunc,PDF,CDF )  )- Q_budget_adj ;% shakiba_3dj_01_2405
2290  %% shakiba_3dj_01_2407
2291  % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,PDF,CDF )  )- Q ;% (178A-36)
2292  new_com=COM_from_matlab+delta_com;
2293  if(delta_com<0)
```

Also pass H^2_{rxffe} out of get_PSDs