

Updating COM 4.5 to align with 3dj D1.0 Annex 178A

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Commit request 4p5_1 per Annex 178A

1. Implement function for MLSD described in Annex 178A
2. Remove access to untested MLSE code
3. And subsequent reporting requirements
4. Add new config parameters to support MLSE

```
MLSE_U1_c_178A.m x +
1 function [MLSE_results] = MLSE_U1_c_178A(param,b,A_s,A_ni,PDF,CDF,PSD_results)
2 if 1
3     num_ui=param.num_ui_RXFF_noise;
4     M=param.samples_per_ui;
5     L=param.levels;
6     sigma_X2=(L^2-1)/(3*(L-1)^2);
7     f_b=param.fb;
8 end
9 COM_from_matlab=20*log10(A_s/A_ni);
10 DER_DFE= 2*(L-1)/L*CDF_ev(A_s,PDF, CDF);
11 S_ni=PSD_results.Sn_rho;
12 R_ni=ifft(S_ni)*f_b;
13 p_scaled_by_b=scalePDF(PDF,b(1));
14 p_j=conv_fct(PDF,p_scaled_by_b);
15 p_scaled_by_1mb=scalePDF(PDF,1-b(1));
16 %
17 j=1; DER_MLSE=0; DER_MLSE_j= inf;
18 P_j.y=cumsum(p_j.y);
19 smallest_relative_change=.0001;
20 %% 178A-37
21 rou=R_ni'/R_ni(1);
22 if DER_DFE <= param.DER_CDR
23     while j <= floor(num_ui/2) && DER_MLSE_j > DER_MLSE*smallest_relative_change
24         u_j=[ 1;(1-b(1))*ones(j-1,1); (-1)^(j+1)*b(1) ];% Eq slide (178A-38)
25         u_j(2:2:end-1)=-u_j(2:2:end-1);
26         % V_j=toeplitz(R_ni(1:j+1).'/R_ni(1));
27         V_j=toeplitz(rou(1:j+1));
28         P_j=cumsum(p_j.y);
29         DER_MLSE_j= ((L-1)/L)^(j-1) * ( CDF_ev( A_s *(u_j.* u_j)^(3/2)/( u_j.*V_j*u_j)^(1/2), p_j, P_j ) ); % CDF_ev is (1-CDF)
30         % DER_MLSE_j= 2*(3/4)^(j) * ( CDF_ev( A_s *(u_j.* u_j)^(3/2)/( u_j.*V_j*u_j)^(0.5), p_j, P_j ) ); % CDF_ev is (1-CDF)
31         DER_MLSE=DER_MLSE+DER_MLSE_j;
32         p_j=conv_fct(p_j,p_scaled_by_1mb);
33         j=j+1;
34     end
35     %% Eq (178A-36) a
36     delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE,PDF,CDF ) )- param.Q;% shakiba_3dj_01_2405
37     % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,PDF,CDF ) )- param.Q;% (178A-36)
38     new_com=COM_from_matlab+delta_com;
39 else
40     warning('MLSE not applied because the DER is less than that required for the CDR to lock')
41     DER_MLSE=NaN;
42     new_com=COM_from_matlab;
43     delta_com=0;
44     delta_com=0;
45 end
46
47 %%
48 MLSE_results.COM_from_matlab=COM_from_matlab;
49 MLSE_results.DER_MLSE=DER_MLSE;
50 MLSE_results.DER_DFE=DER_DFE;
51 MLSE_results.COM=new_com;
52 MLSE_results.delta_com=delta_com;
```

Commit request 4p5_1 per Annex 178A, part 2

REMOVE ACCESS TO UNTESTED MLSE CODE

```
com_ieee8023_93a_460beta1.m | com_ieee8023_93a_450.m
564     VEC_dB = -20*log10(vec_arg);
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,
573     if param.T_O ~=0
574     eye_opening=EH_T_C2M-EH_B_C2M;
575     A_ni=2*A_s-eye_opening;
576     %eq 124E-4
577     else
578     warning('unsupported MLSE option')
579     end
580     if param.T_O ~=0
581     eye_opening=EH_T_C2M-EH_B_C2M;
582     A_ni=2*A_s-eye_opening;
583     %eq 124E-4
```

Commit request 4p5_1 per Annex 178A, part 3

CHANGE VARIABLE NAMES IN PREPARATION FOR REPORTING

com_ieee8023_93a_460beta1.m	com_ieee8023_93a_450.m
584 COM=MLSE_results.COM;	591 COM=MLSE_results.COM_CDF;
585 VEO_mV=eye_opening*1000;	592 VEO_mV=eye_opening*1000;
586 min_COM = min(min_COM, COM);	593 min_COM = min(min_COM, COM);
587 min_VEO_mV = min(min_VEO_mV, VEO_mV);	594 min_VEO_mV = min(min_VEO_mV, VEO_mV);
588 max_VEC_dB = max(max_VEC_dB, VEC_dB);	595 max_VEC_dB = max(max_VEC_dB, VEC_dB);
589 COM_SNR_Struct.delta_COM=MLSE_results.delta_com;	596 output_args.delta_COM=MLSE_results.delta_com_CDF;
590 COM_SNR_Struct.DER_DFE=MLSE_results.DER_DFE;	
591 COM_SNR_Struct.DER_MLSE=MLSE_results.DER_MLSE;	
592 COM_SNR_Struct.delta_VEC=MLSE_results.delta_com-20*log10((10^(MLSE_r	597 output_args.delta_VEC=MLSE_results.delta_com_CDF-20*log10((10^(MLSE_r
593 COM_SNR_Struct.VEC_dB_orig=VEC_dB_orig;	
594 COM_SNR_Struct.VEC_dB=VEC_dB;	
595 else	598 else
596 VEO_mV = 1000*(A_s-A_ni)*2;	599 VEO_mV = 1000*(A_s-A_ni)*2;
597 vec_arg=(A_s-A_ni)/A_s;	600 vec_arg=(A_s-A_ni)/A_s;
598 if vec_arg<eps	601 if vec_arg<eps
599 vec_arg=eps;	602 vec_arg=eps;
600 end	603 end
601 VEC_dB_orig = -20*log10(vec_arg);	604 VEC_dB_orig = -20*log10(vec_arg);
602 VEC_dB=MLSE_results.delta_com-20*log10((10^(MLSE_results.delta_com/2	605 VEC_dB=MLSE_results.delta_com_CDF-20*log10((10^(MLSE_results.delta
603 COM_orig=20*log10(A_s/A_ni);	606 COM_orig=20*log10(A_s/A_ni);
604 COM=MLSE_results.COM;	607 COM=MLSE_results.COM_CDF;

Commit request 4p5_1 per Annex 178A, part 3

COM_SNR_STRUCTURE TO INCLUDE MLSE RESULTS

```
m_ieee8023_93a_460beta1.m                                com_ieee8023_93a_450.m
581     VEC_db_orig = 20*log10(vec_arg); % was negative in 400 beta1 ... Fixed 2-
582     VEC_db=MLSE_results.delta_com-20*log10( (10^(MLSE_results.delta_com/20)-1
583     COM_orig=20*log10(2*A_s/A_ni);
584     COM=MLSE_results.COM;
585     VEO_mv=eye_opening*1000;
586     min_COM = min(min_COM, COM);
587     min_VEO_mv = min(min_VEO_mv,VEO_mv);
588     max_VEC_db = max(max_VEC_db, VEC_db);
589     COM_SNR_Struct.delta_COM=MLSE_results.delta_com;
590     COM_SNR_Struct.DER_DFE=MLSE_results.DER_DFE;
591     COM_SNR_Struct.DER_MLSE=MLSE_results.DER_MLSE;
592     COM_SNR_Struct.delta_VEC=MLSE_results.delta_com-20*log10( (10^(MLSE_resul
593     COM_SNR_Struct.VEC_db_orig=VEC_db_orig;
594     COM_SNR_Struct.VEC_db=VEC_db;
595     else
596     VEO_mv = 1000*(A_s-A_ni)*2;
597     vec_arg=(A_s-A_ni)/A_s;
598     if vec_arg<eps
599     vec_arg=eps;
600     end
601     VEC_db_orig = -20*log10(vec_arg);
602     VEC_db=MLSE_results.delta_com-20*log10( (10^(MLSE_results.delta_com/20)-1
603     COM_orig=20*log10(A_s/A_ni);
604     COM=MLSE_results.COM;
605     min_COM = min(min_COM, COM);
606     min_VEO_mv = min(min_VEO_mv,VEO_mv);
607     max_VEC_db = max(max_VEC_db, VEC_db);
608     COM_SNR_Struct.delta_COM=MLSE_results.delta_com;
609     COM_SNR_Struct.DER_DFE=MLSE_results.DER_DFE;
588     VEC_db_orig = 20*log10(vec_arg); % was negative in 400 beta1 ... Fixed
589     VEC_db=MLSE_results.delta_com_CDF-20*log10( (10^(MLSE_results.delta_com
590     COM_orig=20*log10(2*A_s/A_ni);
591     COM=MLSE_results.COM_CDF;
592     VEO_mv=eye_opening*1000;
593     min_COM = min(min_COM, COM);
594     min_VEO_mv = min(min_VEO_mv,VEO_mv);
595     max_VEC_db = max(max_VEC_db, VEC_db);
596     output_args.delta_COM=MLSE_results.delta_com_CDF;
597     output_args.delta_VEC=MLSE_results.delta_com_CDF-20*log10( (10^(MLSE_re
598     else
599     VEO_mv = 1000*(A_s-A_ni)*2;
600     vec_arg=(A_s-A_ni)/A_s;
601     if vec_arg<eps
602     vec_arg=eps;
603     end
604     VEC_db_orig = -20*log10(vec_arg);
605     VEC_db=MLSE_results.delta_com_CDF-20*log10( (10^(MLSE_results.delta_com
606     COM_orig=20*log10(A_s/A_ni);
607     COM=MLSE_results.COM_CDF;
608     min_COM = min(min_COM, COM);
609     min_VEO_mv = min(min_VEO_mv,VEO_mv);
610     max_VEC_db = max(max_VEC_db, VEC_db);
611     output_args.delta_COM=MLSE_results.delta_com_CDF;
```

Commit request 4p5_1 per Annex 178A, part 3

add new items in COM_SNR_struct to output_args

com_ieee8023_93a_460beta1.m	com_ieee8023_93a_450.m
2824 if OP.MLSE	2768 if OP.MLSE
2825 output_args.COM_orig=COM_SNR_Struct.COM_orig;	2769 output_args.COM_orig=COM_SNR_Struct.COM_orig;
2826 output_args.delta_COM = COM_SNR_Struct.delta_COM;	
2827 output_args.DER_DFE= COM_SNR_Struct.DER_DFE;	
2828 output_args.DER_MLSE= COM_SNR_Struct.DER_MLSE;	
2829 if strcmpi(upper(OP.PHY), 'C2M')	
2830 output_args.VEC_dB_orig= COM_SNR_Struct.VEC_dB_orig;	2770 output_args.VEC_dB_orig=COM_SNR_Struct.VEC_dB_orig;
2831 output_args.delta_VEC = COM_SNR_Struct.delta_VEC;	
2832 output_args.VEC_dB_orig = COM_SNR_Struct.VEC_dB_orig;	
2833 output_args.VEC_dB= COM_SNR_Struct.VEC_dB;	
2834 end	
2835 end	2771 end

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Add 2 new configuration parameters for MLSE

- ❑ DER_CDR (default: 1e-2) maximum DER_DFE that MLSE will be evaluated
 - This replaces the criterial that COM must be greater than zero for MLSE to be evaluated
- ❑ Q (default = 0) MLSE implementation penalty in Anne 178A

com_ieee8023_93a_460beta1.m

```
9179 param.levels = xls_parameter(parameter, 'L'); % number of symbols levels (
9180 param.specBER = xls_parameter(parameter, 'DER_0'); % Target detector error
9181 param.DER_CDR = xls_parameter(parameter, 'DER_CDR', true, 1e-2); % min DER re
```

com_ieee8023_93a_450.m

```
9109 param.levels = xls_parameter(parameter, 'L'); % number of symbols levels
9110 param.specBER = xls_parameter(parameter, 'DER_0'); % Target detector err
```

com_ieee8023_93a_460beta1.m

```
9351 param.flip=xls_parameter(parameter, 'flip', true, 0 ); % exprimental p/n r
9352 param.f_hp=xls_parameter(parameter, 'f_hp', true, 0 ); % for rx testing fo
9353 param.Q=xls_parameter(parameter, 'Q', true, 0 ); % Implementation penalty
```

com_ieee8023_93a_450.m

```
9280 param.flip=xls_parameter(parameter, 'flip', true, 0 ); % exprimental p/
9281 param.f_hp=xls_parameter(parameter, 'f_hp', true, 0 ); % for rx testing
```

+ 9282

Thank You!