COM 3.4 update

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Acknowledgments:
Adam Gregory (Samtec)
Matt Brown (Huawei)
Bill Kirkland and Sameh Elnagar (Semtech)

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Files

- com_ieee8023_93a_340.m
  - COM v3.4
    - Some corrections and better alignment to IEE802.3ck d3.0
    - Added featured for MTF investigations and TP0V measurements
- config_sheets_3p0.zip
  - config_com_ieee8023_93a=3ck_d3p0 _KR_11_30_21.xlsx
  - config_com_ieee8023_93a=3ck_d3p0_CR_CA_11_30_21.xlsx
  - config_com_ieee8023_93a=3ck_d3p0_120F_C2C_11_30_21.xlsx
  - config_com_ieee8023_93a=3ck_d3p0_120g_C2M_tp1a_9_11_30_21.xlsx
  - config_com_ieee8023_93a=3ck_d3p0_MTF_tp1a_11-30-21.xlsx
  - config_com_ieee8023_93a=3ck_d3p0 _TP0V_11_30_21.xlsx
- TP0V_example.m
  - TP0V example code

Updates for estimating C2M Annex 120G performance *(IEEE P802.3ck™ D3.0+)*

Keyword	default	Units	Only used when PMD_type C2M
Optimize_loop_speed_up	0	logical	• Used if T_O not 0. • Speed up the FOM optimization loop at expense of slight loss of accuracy. Mostly used for finding trends.
Sigma_r	0.020	UI	• Used if T_O not 0 and Histogram_Window_Weight = gaussian • This is the sigma_r used to compute the gaussian weighting histogram over T_s +/- T_O for computing VEC and VEO (EH). • Align syntax with .3ck Draft 2.3+ • Replaces QL in COM3.2. (Sigma_r=T_O/QL)
GDC_min	0	Logical or gain	• Ignored if GDC_min=0. • CTF setting where GDC2 + GDC < GDC_min are ignored. GDC and GDC2 are normally a negative numbers. GDC_min would normally be negative, if used. This was implemented incorrectly in COM 3.2. • Align with .3ck Draft 2.3+ for TP4

Mated test fixture (MTF) explorations

Keyword	default	Units	Status	
COMPUTE_RILN	0	Logical	Experimental	• Turn on and off the computation of [1]Reflective Insertion Loss Noise (RILN) • Output is FOM_RILN
COMPUTE_TDILN	0	Logical	Experimental	• Turn on and off the computation of Time Domain Insertion Loss Noise (TDILN) • Output is FOM_TDILN (see slides at end)

- ❑ Support for MTF metrics for COM correlation work
- ❑ ILD plot and FOM_ILD, FOM_RILN, and FOM_TDILN reported for only passed s-parameters.
- ❑ Plot for IL changed to without added packages and boards

[1]H. Dsilva, Sasikala J, A Jain, A Kumar, R Mellitz, A Gregory, B. Lee; "Finding Reflective Insertion Loss Noise and Reflectionless Insertion Loss', DesignCon 2020, Santa Clara, CA

*Added 2 post taps for future work

Keyword	default	
c(2)	0	TX equalizer post cursor tap 2 individual settings or range. If not present ignored
c(3)	0	TX equalizer post cursor tap 3 individual settings or range. If not present ignored

*From Matt Brown

Spreadsheet for Potential MTF exploration

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	53.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.2e-4 0]	nF	[TX RX]
L_s	[0.12 0]	nH	[TX RX]
C_b	[0.3e-4 0]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[15 30; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[0 0 ; 0 0]	mm	[test cases]
z_p (FEXT)	[15 30; 1.8 1.8]	mm	[test cases]
z_p (RX)	[0 0 ; 0 0]	mm	[test cases]
C_p	[0.87e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.415	V	vp/vf=.694
A_fe	0.415	V	vp/vf=.694
A_ne	0.45	V	
L	4		
M	32	Samp/UI	
samples_for_C2M	100	Samp/UI	
T_O	50	mUI	
AC_CM_RMS	0	V	[test cases]
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	[-0.2:0.05:0]		[min:step:max]
c(-2)	[0:0.05:0.1]		[min:step:max]
c(-3)	[-0.1:0.05:0]		[min:step:max]
c(1)	[-0.1:0.05:0]		[min:step:max]
c(2)	0		
c(3)	0		[min:step:max]
N_b	4	UI	
b_max(1)	0.4		As/dffe1
b_max(2..N_b)	[0.15 0.15 0.1]		As/dfe2..N_b
b_min(1)	0.1		As/dffe1
b_min(2..N_b)	[-0.15 - 0.15 - 0.05]		As/dfe2..N_b
g_DC	[-13:1:-0]	dB	[min:step:max]
f_z	12.58	GHz	
f_p1	20	GHz	
f_p2	28	GHz	
g_DC_HP	[-3:0.5:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
G_Qual	[-2 -9 ;-2 -12; -4 -12;-6 -13]	dB	ranges
G2_Qual	[0 -1 -2 -3]	dB	ranges
GDC_Min	0	dB	0 disables check.

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_C2M_host_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	C2M_eval_	
COM_CONTRIBUTION	0	logical
Local Search	2	
Operational		
VEC Pass threshold	12	db
EH_min	10	mV
ERL Pass threshold	7.3	dB
Min_VEO_Test	5	mV
DER_0	0.00001	
T_r	0.0075	ns
FORCE_TR	1	5
PMD_type	C2M	
BREAD_CRUMBS	0	logical
SAVE_CONFIG2MAT	1	logical
PLOT_CM	0	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	800	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0.3e-9]	[port1 port2]
TDR_W_TXPKG	1	
N_bx	0	UI
Tukey_Window	1	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	4.10E-08	V^2/GHz
SNR_TX	32.5	dB
R_LM	0.95	
Optimize_loop_speed_up	0	

Table 93A–3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
ICN & FOM_ILD parameters		
f_v	0.594	*Fb
f_f	0.594	GHz f_r specified in first column
f_n	0.594	GHz
f_2	40	GHz
A_ft	0.600	V
A_nt	0.600	V
COMPUTE_TDILN	1	logical
COMPUTE_RILN	1	logical
Histogram_Window_Weight	Gaussian	gaussian. triangle, rectangle
sigma_r	0.02	sigma in UI fo or gaus.. Wind
Table 92–12 parameters for 16 dB TP0-TP1a loss including MTF		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	
board_tl_tau	5.790E-03	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	234	mm
z_bp (NEXT)	0	mm
z_bp (FEXT)	234	mm
z_bp (RX)	0	mm
C_0	[0.29e-4 0]	nF
C_1	[0.19e-4 0]	nF
Include PCB	1	logical
different for each test fixture		
upodated for D3.0		

Possible topics to be evaluate by correlating to COM or VEC

- FOM_{RILN}
- FOM_{TDILN}
- FOM_{ILD}
- Limiting frequency range.
- Pulse Response MTF specifications

Added and changed outputs highlighted in yellow

code_revision	3.4	code_revision	3.2
RL	struct	RL	struct
Z11est	104.2684	Z11est	104.2684
Z22est	102.4721	Z22est	102.4721
ERL11	12.505	ERL11	12.505
ERL22	9.757	ERL22	9.7543
ERL	9.757	ERL	9.7543
RxFFE		RxFFE	
RxFFEgain		RxFFEgain	
config_file	config_com_ieee8023_93a=3ck_d2p3_MTF_tp1a_11-22-21.xlsx	config_file	config_com_ieee8023_93a=3ck_d2p2_MTF_tp1a_10_15_21.xlsx
file_names	R1 channels--MTF6p2v5_thru	file_names	R4 channels--MTF6p2v5_thru
R_diepad	[50 50]	R_diepad	[50 50]
C_diepad	[1.2e-13 0]	C_diepad	[1.2e-13 0]
L_comp	[1.2e-10 0]	L_comp	[1.2e-10 0]
C_bump	[3e-14 0]	C_bump	[3e-14 0]
levels	4	levels	4
Pkg_len_TX	[30 1.8 0 0]	Pkg_len_TX	[30 1.8 0 0]
Pkg_len_NEXT	[0 0 0 0]	Pkg_len_NEXT	[0 0 0 0]
Pkg_len_FEXT	[30 1.8 0 0]	Pkg_len_FEXT	[30 1.8 0 0]
Pkg_len_RX	[0 0 0 0]	Pkg_len_RX	[0 0 0 0]
pkg_Z_c	[87.5 92.5 100 100;87.5 92.5 100 100]	pkg_Z_c	[87.5 92.5 100 100;87.5 92.5 100 100]
C_v	[0 0]	C_v	[0 0]
baud_rate_GHz	53.125	baud_rate_GHz	53.125
f_Nyquist_GHz	26.5625	f_Nyquist_GHz	26.5625
BER	1.00E-05	BER	1.00E-05
FOM	3.8155	FOM	3.6206
sigma_N	0.0010611	sigma_N	0.0010611
DFE4_RSS	0.0037899	DFE4_RSS	0.0037899
DFE2_RSS	0.018654	DFE2_RSS	0.018654
tail_RSS	0	tail_RSS	0

code_revision	3.4	code_revision	3.2
channel_operating_margin_dB	3.6206	channel_operating_margin_dB	3.6206
available_signal_after_eq_mV	17.9832	available_signal_after_eq_mV	17.9832
peak_uneq_pulse_mV	122.6399	peak_uneq_pulse_mV	122.6399
uneq_FIR_peak_time	2.2465E-09	uneq_FIR_peak_time	2.2465E-09
steady_state_voltage_mV	300.94	steady_state_voltage_mV	300.94
steady_state_voltage_weq_mV	0.075719	steady_state_voltage_weq_mV	0.075719
FOM_ILD	0.12342	FOM_ILD	0.11963
FOM_TDILN	24.4207		
TD_ILN	struct		
FOM_RILN	0.1113	FOM_RILN	0.11121
Peak_ISI_XTK_and_Noise_interference_at_BER_mV	23.7064	Peak_ISI_XTK_and_Noise_interference_at_BER_mV	23.7064
peak_ISI_XTK_interference_at_BER_mV	5.68	peak_ISI_XTK_interference_at_BER_mV	5.68
peak_ISI_interference_at_BER_mV	5.68	peak_ISI_interference_at_BER_mV	5.68
equivalent_ICI_sigma_assuming_PDF_is_Gaussian_mV	1.3318	equivalent_ICI_sigma_assuming_PDF_is_Gaussian_mV	1.3318
peak_MDXTK_interference_at_BER_mV	0	peak_MDXTK_interference_at_BER_mV	0
peak_MDNEXT_interference_at_BER_mV	0	peak_MDNEXT_interference_at_BER_mV	0
peak_MDFEXT_interference_at_BER_mV	0	peak_MDFEXT_interference_at_BER_mV	0
ICN_mV	0	ICN_mV	0
MDNEXT_ICN_92_46_mV	0	MDNEXT_ICN_92_46_mV	0
MDFEXT_ICN_92_47_mV	0	MDFEXT_ICN_92_47_mV	0
equivalent_ICN_assuming_PDF_is_Gaussian_mV	0	equivalent_ICN_assuming_PDF_is_Gaussian_mV	0
SNR_ISI_XTK_normalized_1_sigma	22.6085	SNR_ISI_XTK_normalized_1_sigma	22.6085
SNR_ISI_est	33.5838	SNR_ISI_est	32.9414
Pmax_by_Vf_est	4.08E-01	Pmax_by_Vf_est	4.08E-01
CTLE_zero_poles	[12580000000 28000000000 20000000000]	CTLE_zero_poles	[12580000000 28000000000 20000000000]
CTLE_DC_gain_dB	-7	CTLE_DC_gain_dB	-7
g_DC_HP	-2.5	g_DC_HP	-2.5
HP_poles_zero	1328125000	HP_poles_zero	1328125000
TXLE_taps	[0 0.05 -0.2 0.75 0]	TXLE_taps	[0 0.05 -0.2 0.75 0]

- FOM_ILD in 3.4 is only for the MTF s-parameters
- FOM_ILD in 3.2 is for the MTF s-parameters plus the added board.

2 outputs re-defined and 2 added

code_revision	3.4	code_revision	3.2
Pre2Pmax	0.26667	Pre2Pmax	0.26667
DFE_taps	[0.3259115690035€	DFE_taps	[0.3259115690035
sgm_Ani__isi_xt_noise	0.0025672	sgm_Ani__isi_xt_noise	0.0025673
sgm_isi_xt	0.0015788	sgm_isi_xt	0.0015788
sgm_isi	0.0015788	sgm_isi	0.0015788
sgm_xt	0	sgm_xt	0
sgm_noise__gaussian_noise_p_DD	0.0020244	sgm_noise__gaussian_noise_p_DD	0.0020244
sgm_p_DD	0.00096333	sgm_p_DD	0.00096335
sgm_gaussian_noise	0.0017805	sgm_gaussian_noise	0.0017805
sgm_G	0.0017808	sgm_G	0.0017809
sgm_rjit	0.00048161	sgm_rjit	0.00048167
sgm_N	0.0010611	sgm_N	0.0010611
sgm_TX	0.0013467	sgm_TX	0.0013467
total_IL_wpkgs_dB_at_Fnq	19.82	total_IL_wpkgs_dB_at_Fnq	19.82
IL_dB_channel_only_at_Fnq	6.2031	IL_dB_channel_only_at_Fnq	15.5943
fitted_IL_dB_at_Fnq	6.1631	fitted_IL_dB_at_Fnq	15.483
cable__assembley_loss	6.2031	cable__assembley_loss	6.2031
loss_with_PCB	15.5943		
VEC_dB	9.3481	VEC_dB	9.3481
VEO_mV	12.26	VEO_mV	12.26
EW_UI_est	[0.17 0.19 0.17]	EW_UI_est	[0.17 0.19 0.17]
eye_contour	[-0.05727 0.01679 -	eye_contour	[-0.05727 0.01679
VEO_window_mUI	50	VEO_window_mUI	50
COM_dB	3.6206	COM_dB	3.6206
DER_thresh	2.688E-24	DER_thresh	2.7088E-24
rtmin	1.3918		

V3.2

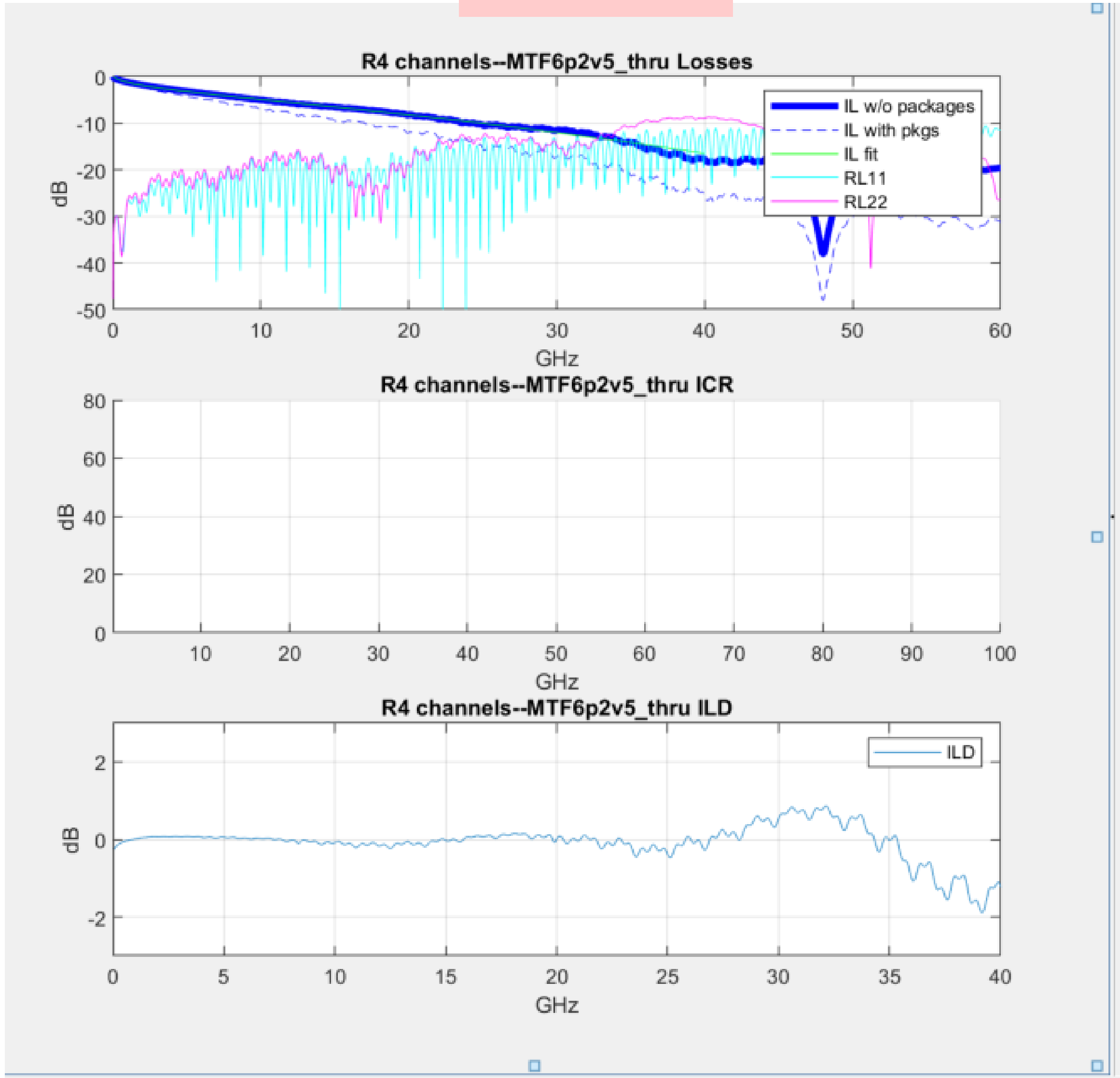
- ❑ IL_dB_channel_only_at_Fnq and fitted_IL_dB_at_Fnq include the add PCB

V3.4

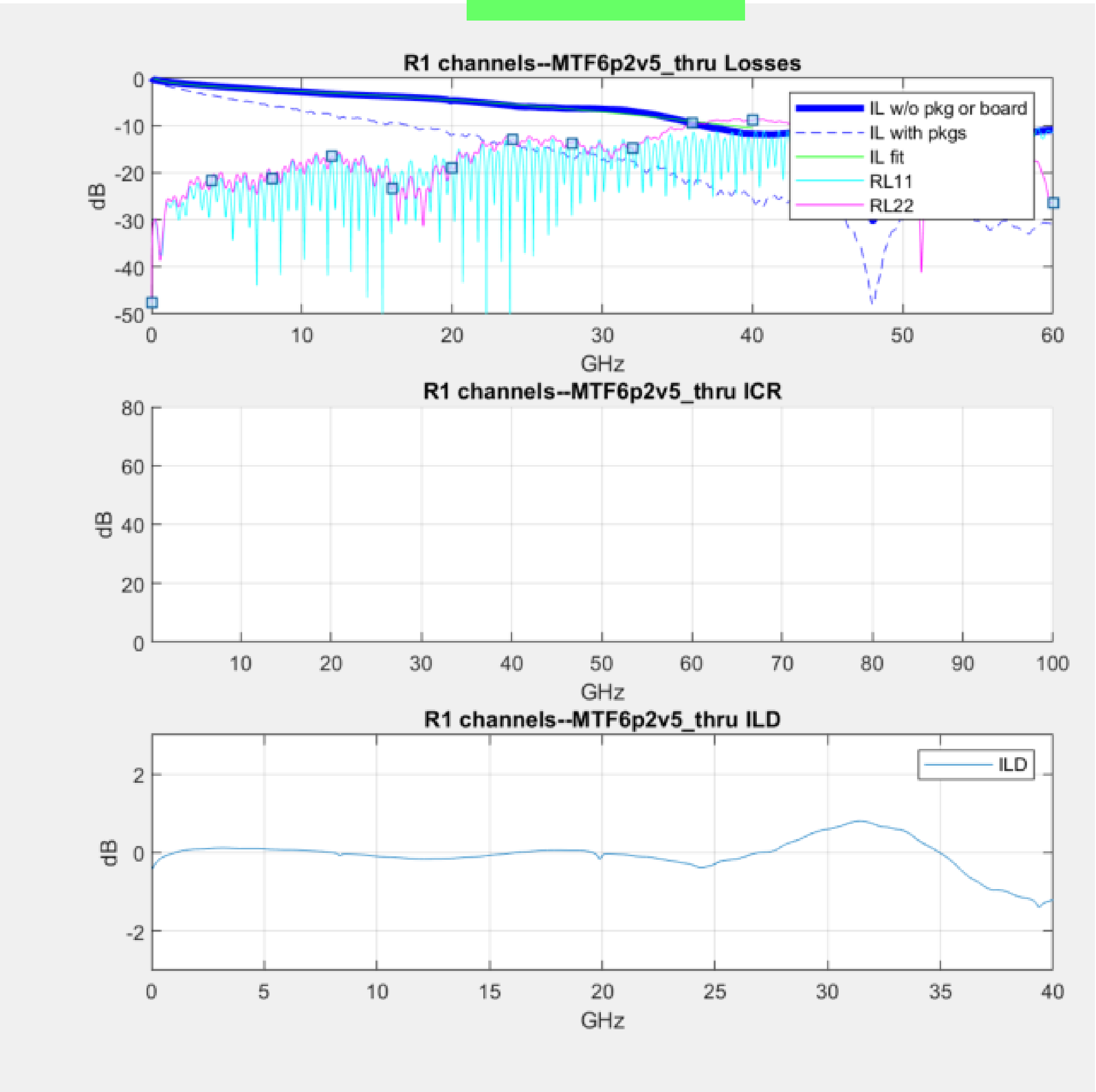
- ❑ IL_dB_channel_only_at_Fnq and fitted_IL_dB_at_Fnq does not include the add PCB
- ❑ Added runtime (minutes) output parameter

IL and ILD plots represent passed s-parameters (MTF)

COM 3.2



COM 3.4



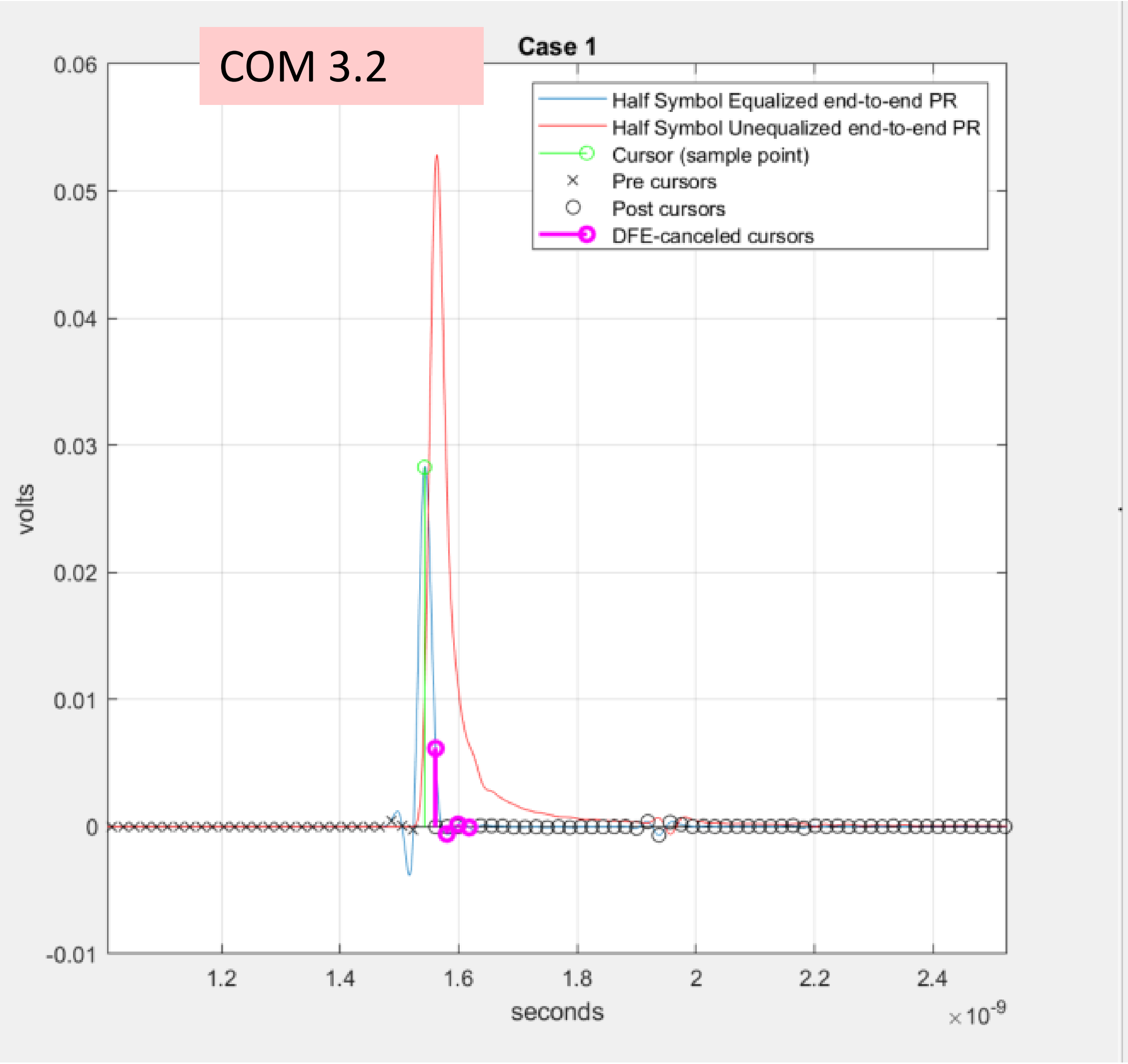
Other

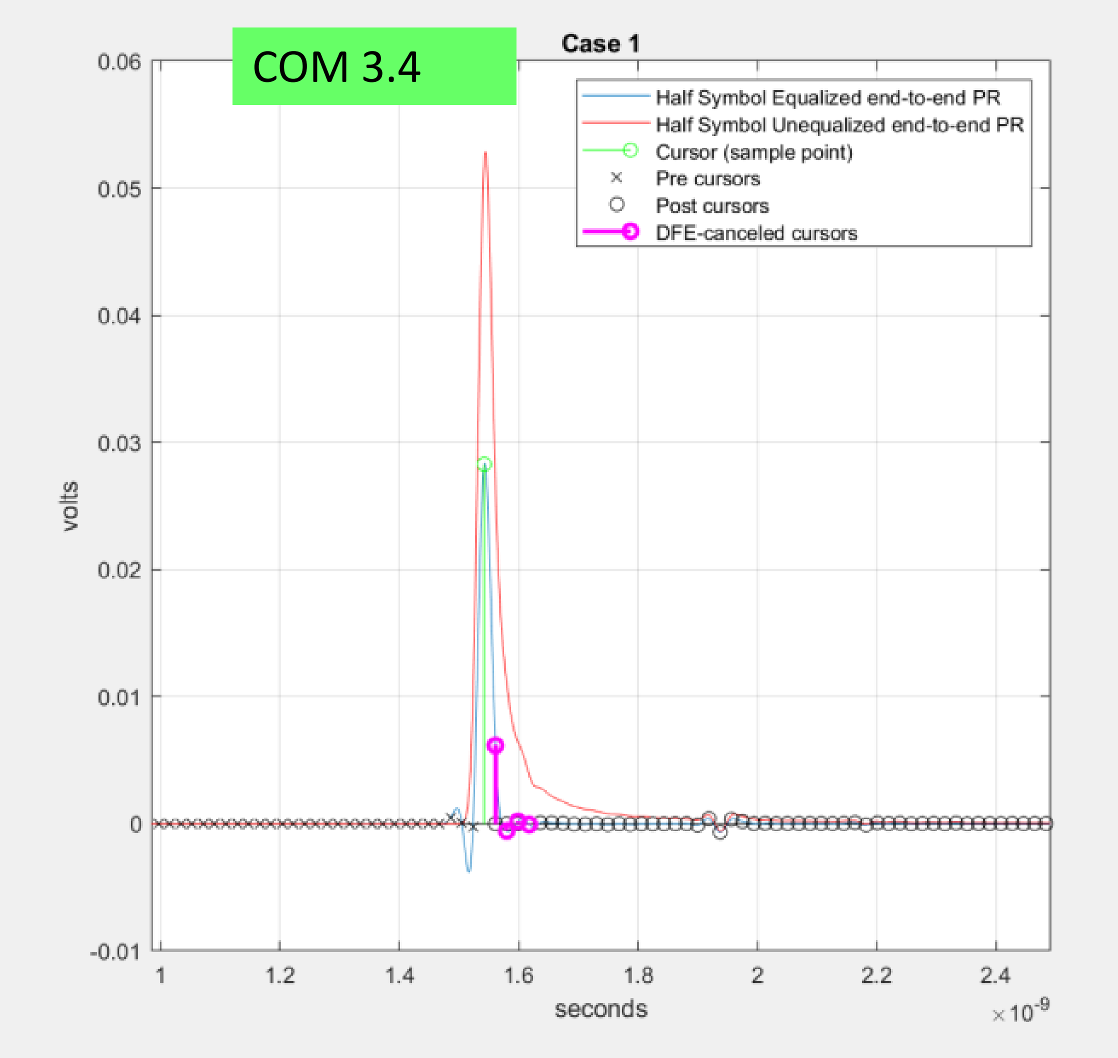
*RX FFE noise correction

- Error introduced in COM 3.1 for computed Rx noise when using an Rx FFE.
- Rx FFE is not normal COM usages

*from Bill Kirkland and Sameh Elnagar (Semtech)

Better alignment of displayed pulse responses





Notes on TP0V_example.m

- Example for TP0v determination of Vp, Vp/Vf, and ERL
- TP0V_eample(COM versions 3.4 and later
- Author: Richard Mellitz
- Code snipits by Adam Gregory
- syntax:
  - my_results=TP0V_example('com_m_file','config_file','fixture_file','s2p_measurement_file')
  - com_m_file is without the .m extension
- example:
  - my_results=...
    TP0V_example('com_ieee8023_93a_','config_com_ieee8023_93a=3ck_d3p0 _TP0V_11_30_21.xlsx',...
    ‘C:\OneDrive - Samtec\TPV\channels\test_fixture_BE70_5p0_50mm.s4p',...
    'C:\OneDrive - Samtec\TPV\channels\test_fixture_BE70_5p0_50mm_wpkg.s2p’);
    - Results ...
    - dERL = -2.41
    - V_peak Ref = 406.4
    - Vpeak/Vf Ref = 0.447

Background: Time Domain Insertion Loss Noise (TDILN)

Review of complex Insertion loss fit for moore_01_0311.pdf

The complex insertion loss H is fitted to a low refection transmission line equation below

$$H = e^{x}$$

i.e. $H^{(0)}(f) \rightarrow complex\ IL$

$$\log(H_{fit}) = x \cong \gamma_0 + \gamma_1\sqrt{f} + \gamma_2 f + \gamma_4 f^2$$

$$\gamma_i = \alpha_i + j\beta_i$$

$$F_w = \begin{bmatrix} H(f_1) & H(f_1)\sqrt{f_1} & H(f_1)f_1 & H(f_1)f_1^2 \\ H(f_2) & H(f_1)\sqrt{f_1} & H(f_2)f_2 & H(f_2)f_2^2 \\ \vdots & \vdots & \vdots & \vdots \\ H(f_N) & H(f_N)\sqrt{f_N} & H(f_N)f_N & H(f_N)f_N^2 \end{bmatrix} \qquad y = \begin{bmatrix} H(f_1)\log(H(f_1)) \\ H(f_2)\log(H(f_2)) \\ \vdots \\ H(f_N)\log(H(f_N)) \end{bmatrix}$$

$$\gamma = \begin{bmatrix} \gamma_0 \\ \gamma_1 \\ \gamma_2 \\ \gamma_4 \end{bmatrix}$$

$$\gamma^{lms} = (F_w^T F_w)^{-1} F_w^T y$$

$$x^{lms} = \gamma_0^{lms} + \gamma_1^{lms}\sqrt{f} + \gamma_2^{lms} f + \gamma_4^{lms} f^2 \qquad H_{fit} = e^{x^{lms}}$$

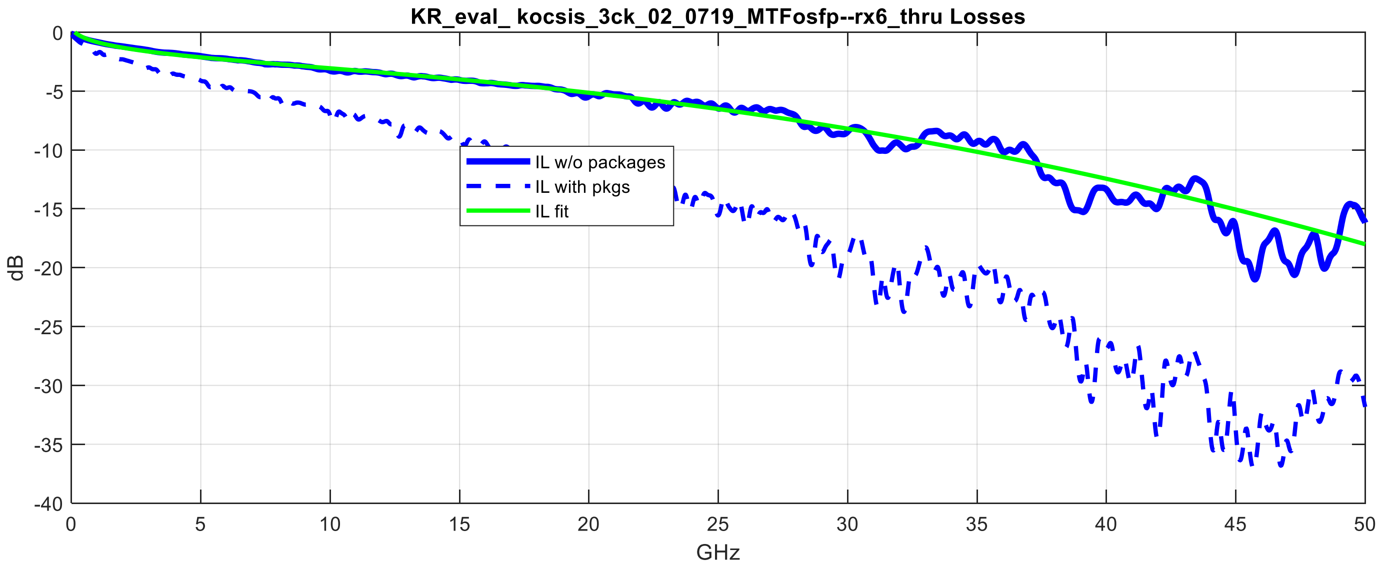
i.e. ${H_{fit}}^{(0)}(f)$ $is\ the\ complex\ fit \rightarrow ILfit(f)$

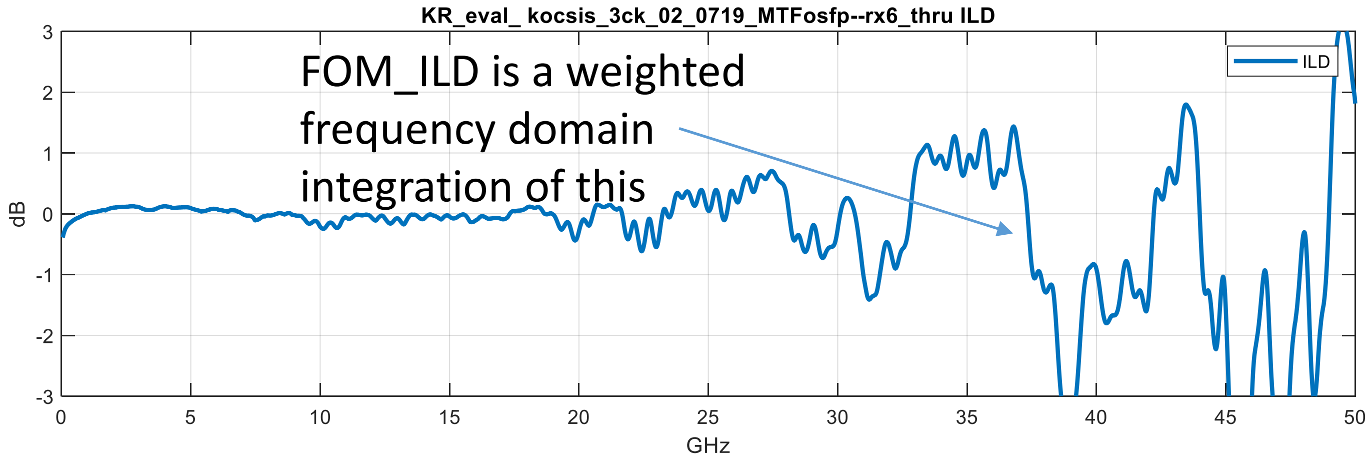
Reference slide 9 of
https://www.ieee802.org/3/100GCU/public/mar11/moore_01_0311.pdf

The next step is to convert H and H_{fit} into pulse responses

- From Annex 93A equation(93A-23,24) results in a pulse response
  - $X(f) = A_t T_b sinc(f T_b)$
  - $h^k(t) = \int_{-\infty}^{\infty} X(f) H^{(k)}(f) e^{-2jft} df$
    - k is 0 for the victim channel insertion loss
    - f is frequency
    - t is time
    - T_b is the symbol time or UI and is $1/f_b$ t
    - A_t is the amplitude of the signal
  - The pulse response PR is sampled pulse response *pr(t)* for the measured complex insertion loss IL(f)
    - $PR = pr(t) = \int_{-\infty}^{\infty} X(f) IL(f) e^{-2jft} df$
  - The pulse response PR_{fit} is sampled pulse response *$pr_{fit}(t)$* for the fitted complex insertion loss $IL_{fit}(f)$
    - $PR_{fit} = prfit(t) = \int_{-\infty}^{\infty} X(f) IL_{fit}(f) e^{-2jft} df$

Use complex fit for IL instead of magnitude only





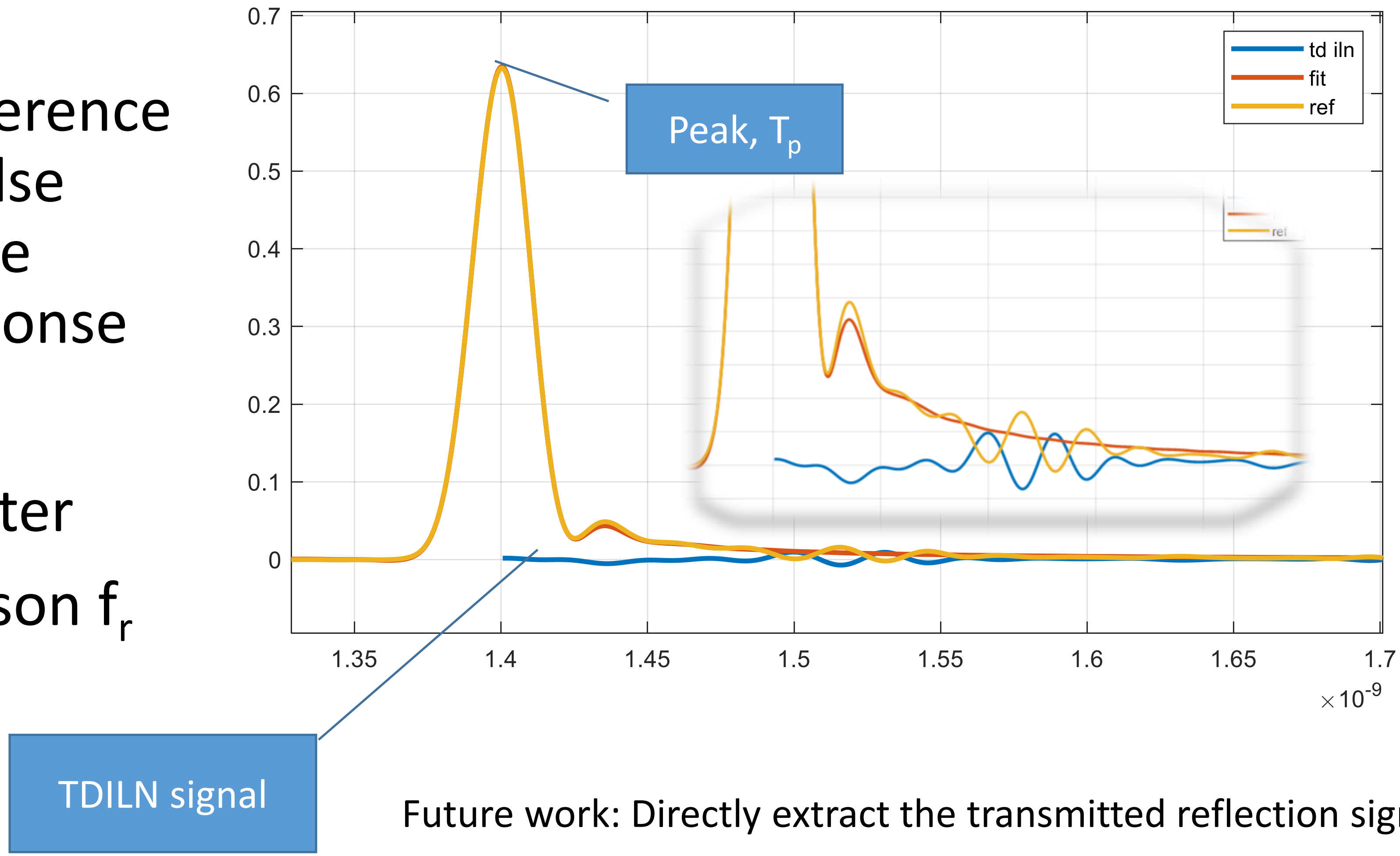
- ❑ Fitted Pulse response is computed
- ❑ Since the fitted IL is complex a pulse response may be computed

Example for 100 Gbps PAM4

TDILN is the difference between the pulse response and the fitted pulse response

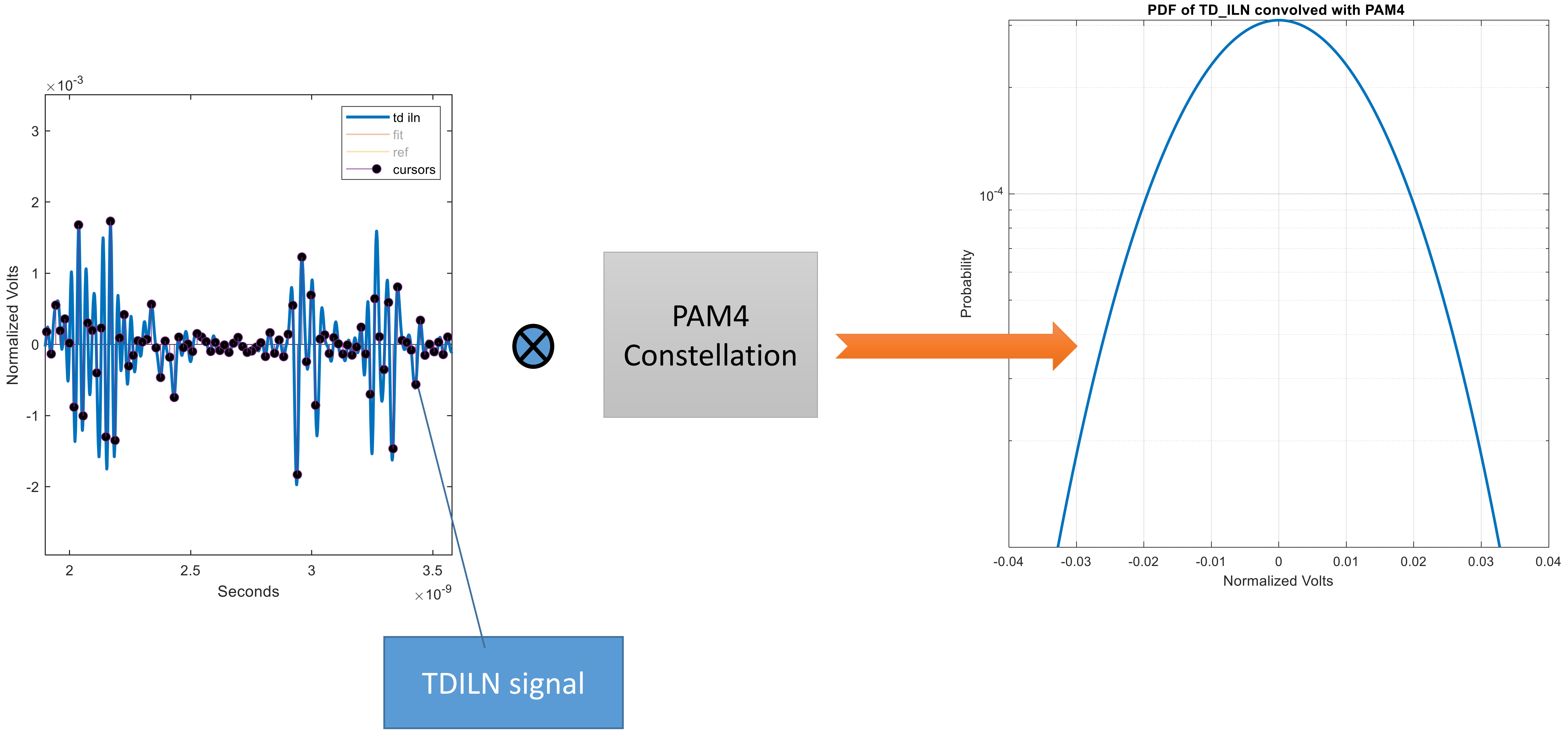
Using Filters:

- ❑ Gaussian T_r filter
- ❑ Bessel–Thomson f_r

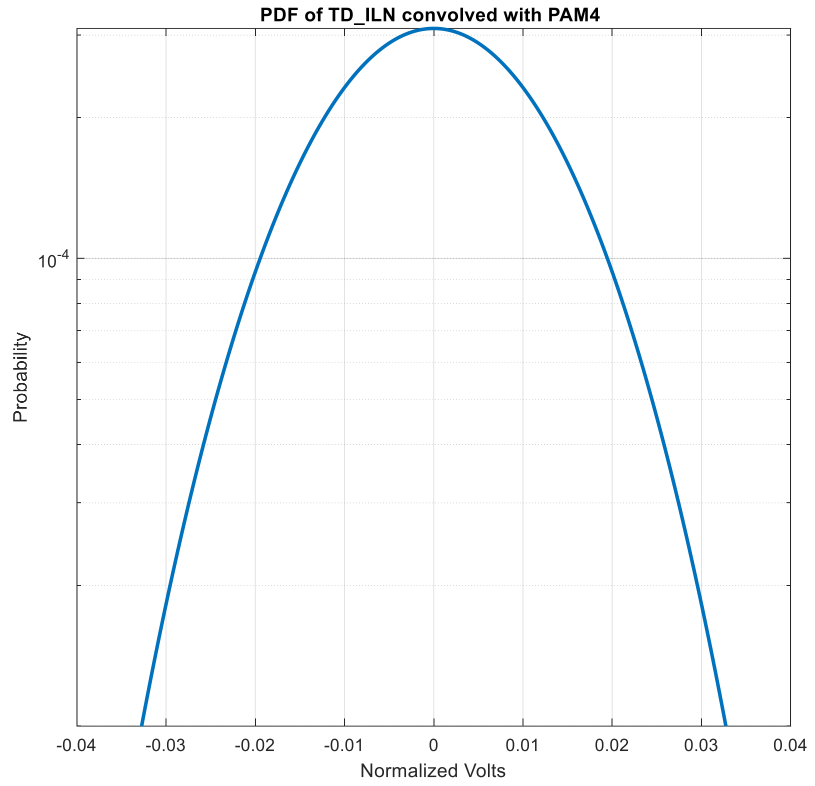


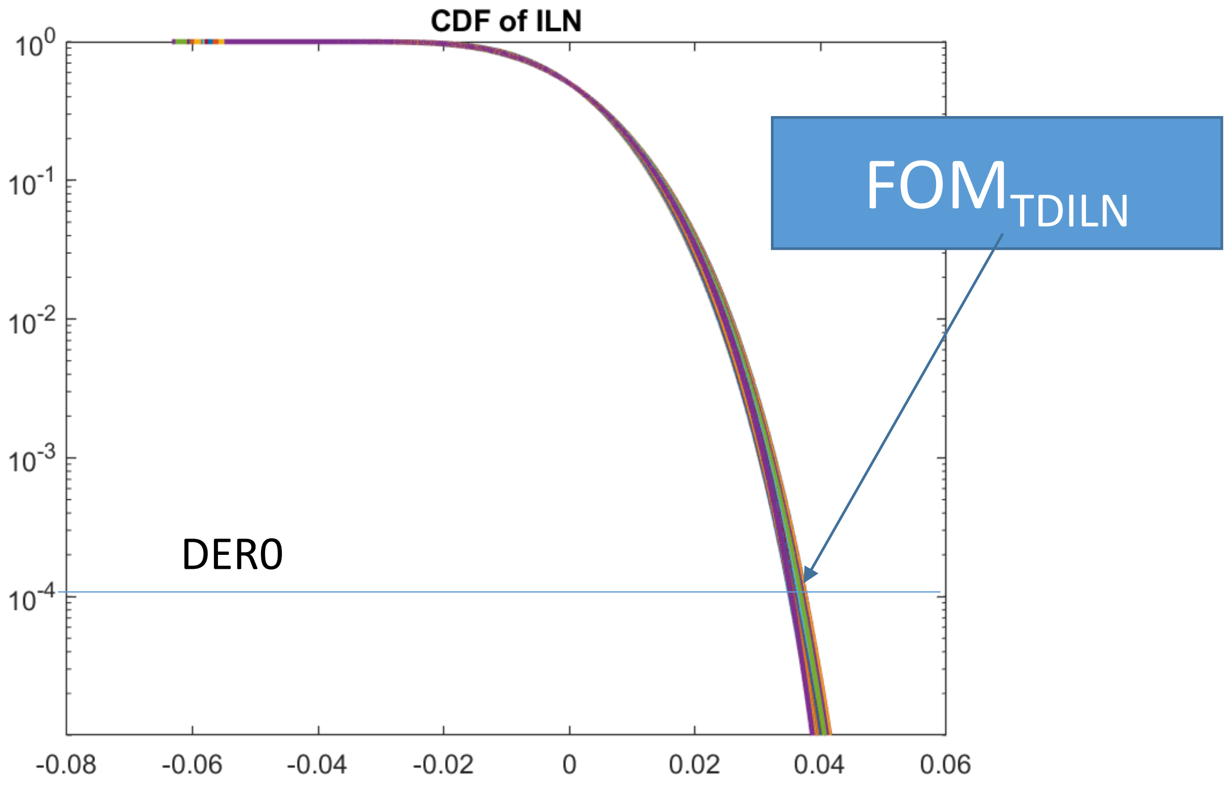
Future work: Directly extract the transmitted reflection signal

Converting TD_ILN to a PDF for PAM4



FOM_{TDILN} is computed from the ILN CDF





FOM_TDILN

- TDILN in normalized volts
- Normalize TDILN_dB as ratio removes dependency on voltage amplitude

$$FOM_{TDILN} = 20log_{10}\left(\frac{peak}{TDILN}\right)$$