COM Reference RX Progress Update – 29 February 2024

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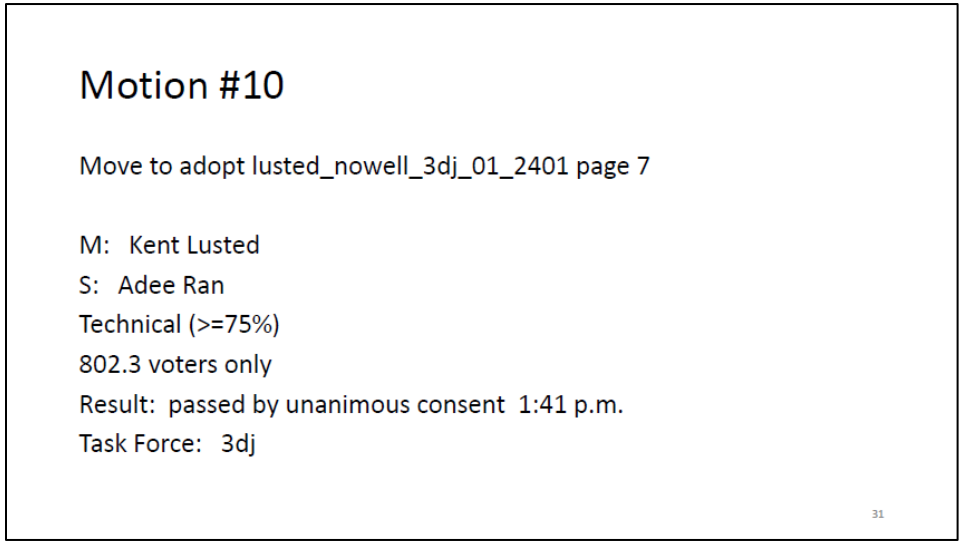
Adopted COM Ref RX Framework

- At the January 2024 interim meeting, the TF adopted (related to COM):
  - New reference RX framework of RXFFE+1DFE
  - New MMSE coefficient optimization procedure

https://www.ieee802.org/3/dj/public/24_01/healey_3dj_01_2401.pdf



Motion #10

Move to adopt lusted_nowell_3dj_01_2401 page 7

M: Kent Lusted
S: Adee Ran
Technical (>=75%)
802.3 voters only
Result: passed by unanimous consent 1:41 p.m.
Task Force: 3dj

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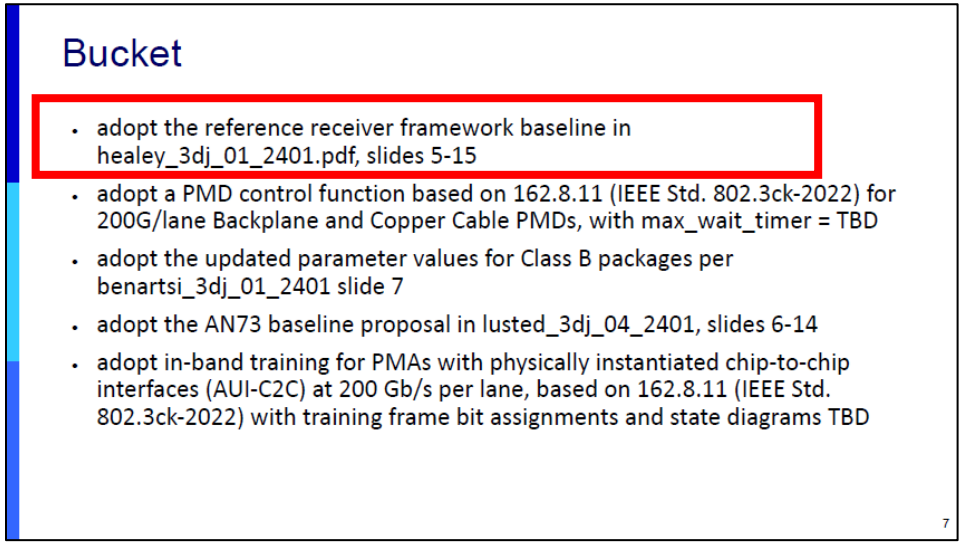

Bucket

- adopt the reference receiver framework baseline in healey_3dj_01_2401.pdf, slides 5-15
- adopt a PMD control function based on 162.8.11 (IEEE Std. 802.3ck-2022) for 200G/lane Backplane and Copper Cable PMDs, with max_wait_timer = TBD
- adopt the updated parameter values for Class B packages per benartsi_3dj_01_2401 slide 7
- adopt the AN73 baseline proposal in lusted_3dj_04_2401, slides 6-14
- adopt in-band training for PMAs with physically instantiated chip-to-chip interfaces (AUI-C2C) at 200 Gb/s per lane, based on 162.8.11 (IEEE Std. 802.3ck-2022) with training frame bit assignments and state diagrams TBD

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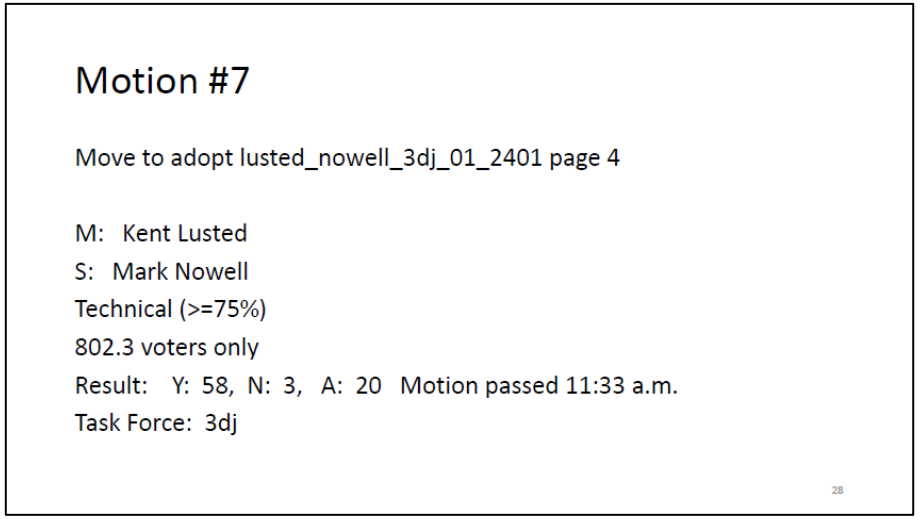
Adopted MLSE Equation for Evaluation of Channels

- At the January 2024 interim meeting, the TF adopted (related to COM) the MLSE Eq U1.c for evaluation
  - Implementation penalty = TBD
- Note: No commitment to use MLSE effect in COM for any electrical interface or PMD

https://www.ieee802.org/3/dj/public/24_01/shakiba_3dj_01b_2401.pdf



Motion #7

Move to adopt lusted_nowell_3dj_01_2401 page 4

M: Kent Lusted
S: Mark Nowell
Technical (>=75%)
802.3 voters only
Result: Y: 58, N: 3, A: 20 Motion passed 11:33 a.m.
Task Force: 3dj

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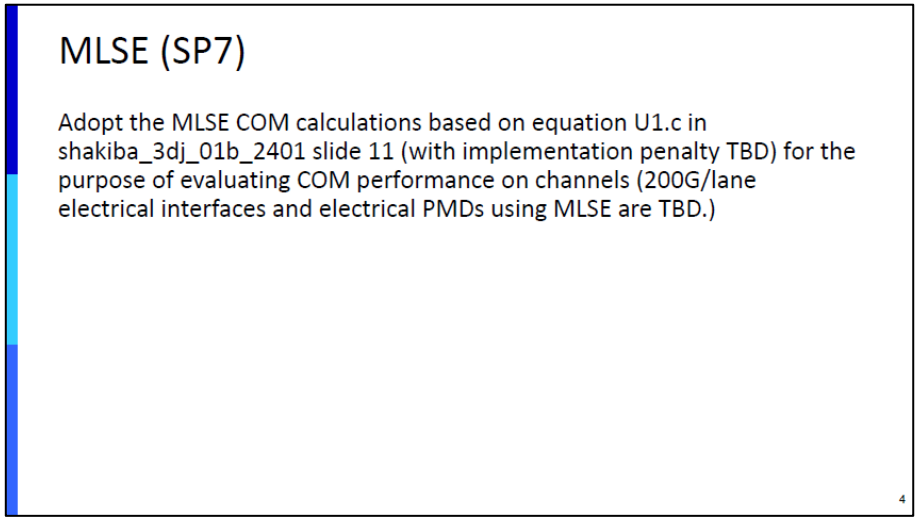

MLSE (SP7)

Adopt the MLSE COM calculations based on equation U1.c in shakiba_3dj_01b_2401 slide 11 (with implementation penalty TBD) for the purpose of evaluating COM performance on channels (200G/lane electrical interfaces and electrical PMDs using MLSE are TBD.)

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COM Work Item List

Currently in development:

- RXFFE + 1 DFE framework and MMSE coef optimization

In the queue:

- FFE Floating taps
- MLSE Eq U1.c

Current Status – 26 February

- Functions added or changed in the COM version 4.3:
  - MMSE and get_PSDs (for determining Rx FFE settings and noise)
    - Implement equations in healey_3dj_01_2401
  - Main program (computes COM)
    - Modified function get_PDF and Create_Noise_PDF and added a get_PSDs reference
    - Uses worst case crosstalk index found in MMSE process
    - Sigma_Tx derived from SNR_TX uses equations in healey_3dj_01_2401
  - optimize_fom (loops to find best equalization settings)
    - Invokes MMSE and get_PSDs function if new configuration keyword is active
    - New keywords added to read_ParamConfigFile
      - “num_ui_RXFF_noise” and “FFE_OPT_METHOD” (“”MMSE” or “FV-LMS”)

Observations with COM v4.3

- Margin seems “quite a bit improved” from prior versions (see slide 7)
  - Initial bench testing was only for a few cases
- Execution time could be up to 30x longer when sweeping TXFFE and CTLE settings
  - Use small solution space to start.
    - Suggestion: start with 2 pre TXFFE taps with coarse steps, a few G_DC2 settings, and no G_DC (make G_DC=0 and set poles and zeros to 10^{10} GHz).
  - Results for one case, in slide 7
    - RxFFE pre6/post24 used with all taps constrained to +/- 1.
    - More configuration details and channel information in the back up section
- Consider “LOCAL SEARCH” set to 2 (improves speed but less optimal results)
  - “LOCAL SEARCH” = 0 is used for a full grid search
  - “num_ui_RXFF_noise” is the number of UI to be used to compute noise over
    - For the few case tried, num_ui_RXFF_noise = 1024 seems to be the point of diminishing return (~0.01 dB COM difference)
      - Some cable channels have measurable energy which can span over 3000 UI !
      - However, most of these channels have 99.9% or their noise energy in the first 1000 UI.

Weaver_3dj_elec_01_230622 Example

Old Method	New Method	New Method
Local Search = 2 **FFE_OPT_METHOD = FV-LMS**	**Local Search = 2** **num_ui_RXFF_noise =1024** **FFE_OPT_METHOD = MMSE**	**Local Search = 0** **num_ui_RXFF_noise = 4096** **FFE_OPT_METHOD = MMSE**
FOM: 13 dB	FOM: 31 dB	FOM: 31 dB
TXFFE coefficients: [0 -0.05 0.95 0]	TXFFE coefficients: [0 0 1 0]	TXFFE coefficients: [0 0 1 0]
SNR ISI: 28 dB	SNR ISI: 28 dB	SNR ISI: 28 dB
CTLE DC gain: -4 dB	CTLE DC gain: -3 dB	CTLE DC gain: -3 dB
CTF peaking gain: -2.4 dB	CTF peaking gain: -2 dB	CTF peaking gain: -2 dB
Symbol Available signal: 0.0074777	Symbol Available signal: 0.0076859	Symbol Available signal: 0.0076868
*Die to die loss = 38.2359 dB	*Die to die loss = 38.2359 dB	*Die to die loss = 38.2359 dB
run time = **0.923739 min**	run time = **1.86633 min**	run time = **51.6935 min**
WC All cases FAIL ... COM = 1.692 dB	WC All cases FAIL ... COM = 2.025 dB	WC All cases FAIL ... COM = 2.015 dB

"Die to Die loss" is new in command window

Note: Channel used was KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_thru (see slide 10)

Next Steps

- Participants are asked to review COM code changes to ensure alignment with the adopted proposals per healey_3dj_01_2401 slides 5-15
  - Need a few volunteers to cross check a few channel analysis results in healey_3dj_01_2401
- Please start using COM v4.3 in channel analysis and consider contributions for the March Plenary
  - Not functional or untested in the current v4.3 release are (Do Not Use):
    - FFE floating taps
    - MLSE: no U1.c MLSE function (U0 EQ still in the code)
- Send bug reports or functional issues to Kent and Rich

Summary

- The COM release v4.3 is focused on implementation of adopted RXFFE + 1 DFE framework and MMSE coef optimization
  - Other adopted features (floating taps, MLSE Eq U1.c) are not functional or untested
- We must get the adopted framework and functionality correct **FIRST** … then work on improving run time and adding the remaining adopted features (floating taps, MLSE Eq U1.c)
  - Other requests/changes/improvements/features/etc are not being considered at this time until the backlog is cleared
- More releases planned soon that incorporate the other adopted features and/or bug fixes
  - Next update at March 2024 Plenary meeting

Channel files used are from weaver_3dj_elec_01_230622

Subdirectory: NPC_300mm_BP_800mm_NPC_300mm_room_temp

KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_thru	
KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_FEXT1	KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_NEXT1
KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_FEXT2	KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_NEXT2
KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_FEXT3	KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_NEXT3
KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_FEXT4	KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_NEXT4
KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_FEXT5	KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_NEXT5
KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_FEXT6	KR_ch_3in_PCB_NPC_300mm_29AWG_BP_800mm_27AWG_NPC_300mm_29AWG_NEXT6

Main Configuration

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
R_0	5.00E+01	Ohm	
R_d	[50 50]	Ohm	[TX RX]
PKG_NAME	**PKG_HiR_CLASSB PKG_HiR_CLASSB**		TX RX
A_v	0.413	V	
A_fe	0.413	V	
A_ne	0.608	V	
z_p select	[3]		
L	4		
M	32		
filter and Eq			
f_r	0.58	*fb	
c(0)	0.55		min
c(-1)	[-0.4:0.05:0]		[min:step:max]
c(-2)	[0:.05:0.1]		[min:step:max]
c(-3)	0		[min:step:max]
c(-4)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	1	UI	
b_max(1)	0.75		As/dffe1
b_max(2..N_b)	0.3		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	-0.15	S	As/dfe2..N_b
g_DC	[-10:1:-3]	dB	[min:step:max]
f_z	42.50	GHz	
f_p1	42.50	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-5:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\CRKR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_set1_eval_	
COM_CONTRIBUTION	1	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	4000	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	20	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	4.00E-09	dB
SNR_TX	33	
R_LM	0.95	

baseline
new
relevant for RxFFE
adjusted in experiment

Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	2 92 ; 70 70; 80 80; 100 10	Ohm	
z_p (TX)	; 1 1 1 1; 1 1 1 1 ; 0.5 0	mm	[test cases to run]
z_p (NEXT)	; 1 1 1 1; 1 1 1 1 ; 0.5 0	mm	[test cases]
z_p (FEXT)	; 1 1 1 1; 1 1 1 1 ; 0.5 0	mm	[test cases]
z_p (RX)	; 1 1 1 1; 1 1 1 1 ; 0.5 0	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[test cases]
Operational			
ERL Pass threshold	10	dB	
COM Pass threshold	3	db	
DER_0	1.00E-04		
T_r	0.00400	ns	
FORCE_TR	1	logical	
PMD_type	C2C		
EW	1		
MLSE	0	logical	
ts_anchor	1		
sample_adjustment	[-8 8]		
Local Search	2		
Filter: Rx FFE			
ffe_pre_tap_len	**6**	UI	
ffe_post_tap_len	24	UI	
ffe_pre_tap1_max	1	(normalized)	
ffe_post_tap1_max	1	(normalized)	
ffe_tapn_max	1	(normalized)	
FFE_OPT_METHOD	MMSE		FV-LMS or MMSE
num_ui_RXFF_noise	1024		
Floating Tap Control			
N_bg	**0**	0 1 2 or 3 groups	
N_bf	4	taps per group	
N_f	80	UI span for floating taps	
bmaxg	0.2	max DFE value for floating taps	
B_float_RSS_MAX	1	rss tail tap limit	
N_tail_start	25	(UI) start of tail taps limit	

SAVE_CONFIG2MAT	0	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
ICN parameters		
f_v	0.278	Fb
f_f	0.278	Fb
f_n	0.278	Fb
f_2	61.625	GHz
A_ft	0.450	V
A_nt	0.450	V

Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 6.44084e-4 3.6036e-05]*	1.4 db/in @ 53.125G
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	*32*	mm
z_bp (NEXT)	*32*	mm
z_bp (FEXT)	*32*	mm
z_bp (RX)	*32*	mm
C_0	[0.2e-4 0]	nF
C_1	[0.2e-4 0]	nF
Include PCB	**0**	**logical**
Seletions (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	*0.02*	UI

Note: the values in white boxes and red boxes listed here are <u>not</u> baseline proposed parameter values.

Configuration for Packages

Adopted (green items))

.START	PKG_LowR_CLASSA	[2.44 5.7] db	
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4057 0.4143 0.4143 0.4143]	V	Vf=0.400
A_fe	[0.4057 0.4143 0.4143 0.4143]	V	Vf=0.399
A_ne	[0.600 0.600 0.600 0.600]	V	Vf=0.400
.END			

.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db	
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0.0005 0.00065 0.000293]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[8 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[8 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (FEXT)	[8 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[8 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.400
A_fe	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.399
A_ne	[0.600 0.600 0.600 0.600]	V	Vf=0.400
.END			

Not Adopted, reference only

.START	PKG_Module		
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.400
A_fe	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.399
A_ne	[0.600 0.600 0.600 0.600]	V	Vf=0.400
.END			

.START	PKG_Null		
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[5e-4 0.001 0.03]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[0 0 0 0 ;0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[0 0 0 0 ;0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[0 0 0 0 ;0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[0 0 0 0 ;0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0 0]	nF	[TX RX]
A_v	0.5	V	Vf=0.400
A_fe	0.5	V	Vf=0.400
A_ne	0.61	V	
.END			