



gEEK[®] speak

Mechanics of Running COM

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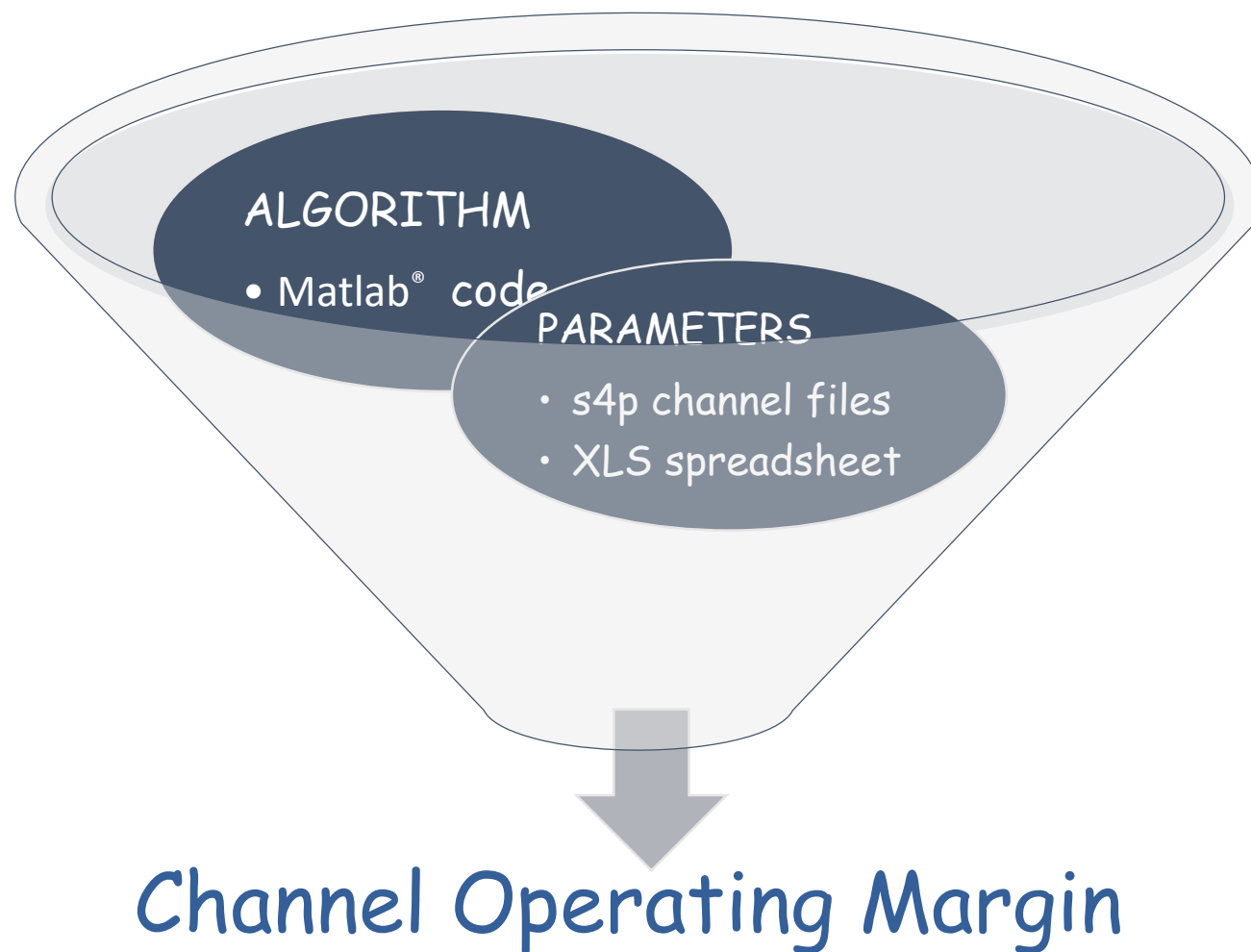
Agenda

- COM: “Hello World”¹
- What you need to get started
- A few early configuration examples
 - 25 G NRZ/PAM4
- Packages
- Latest COM script examples
 - 100 G PAM4
- Using the COM compute to compute ERL only
- Touch on Advanced Topic
 - ERL for test point V
- Not in this presentation
 - COM concepts
 - Transmitter testing
 - Passing parameter into COM

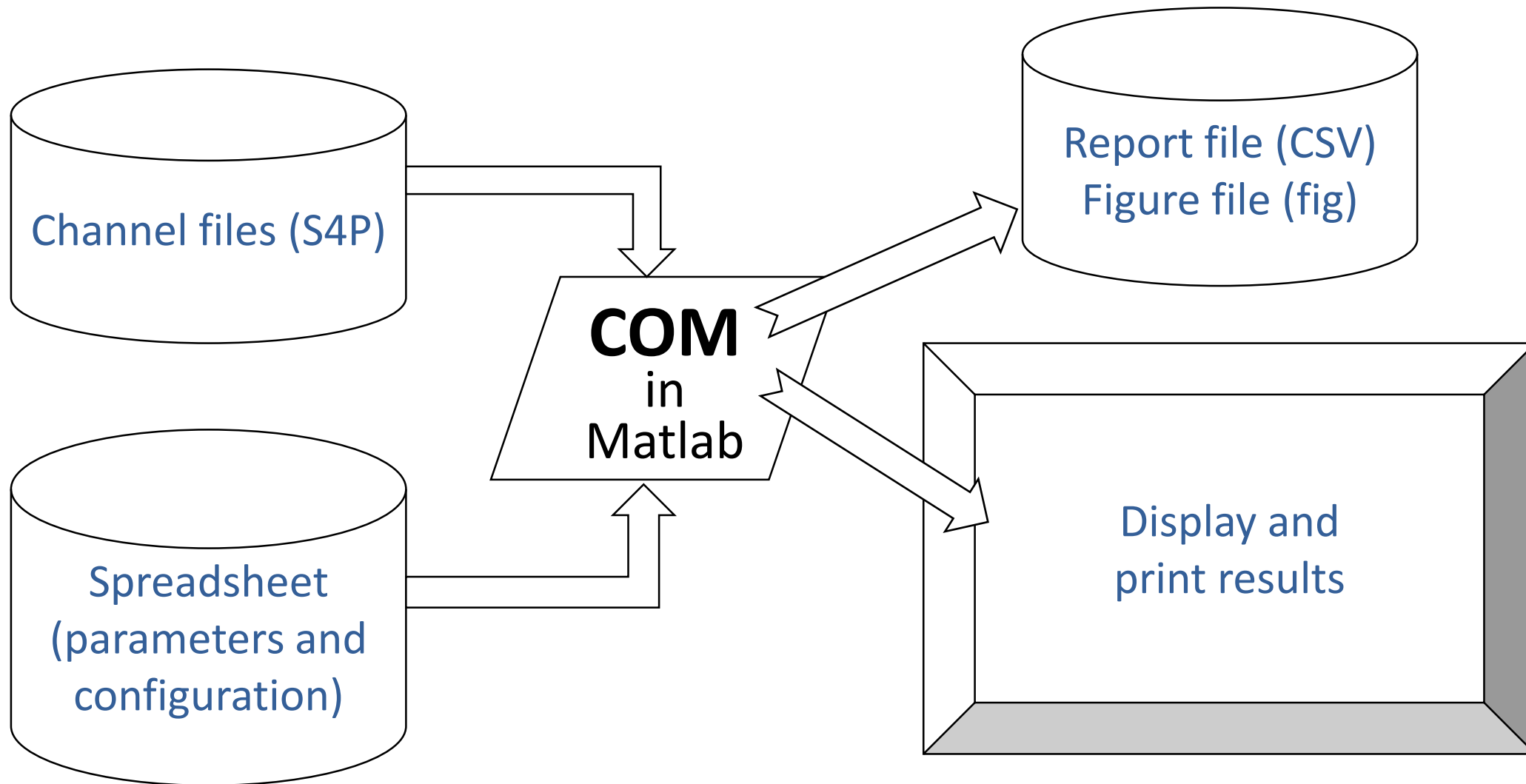
¹ Kernighan, Brian W.; Ritchie, Dennis M. (February 1978). The C Programming Language (1st ed.). Englewood Cliffs, NJ: Prentice Hall. ISBN 0-13-110163-3.

What You Need to get Started

- A set of s4p S-parameters
 - Called channel files
- COM Matlab® Script
 - r3.1 or higher
- A Configuration Spreadsheet
 - Corresponding to a particular standards

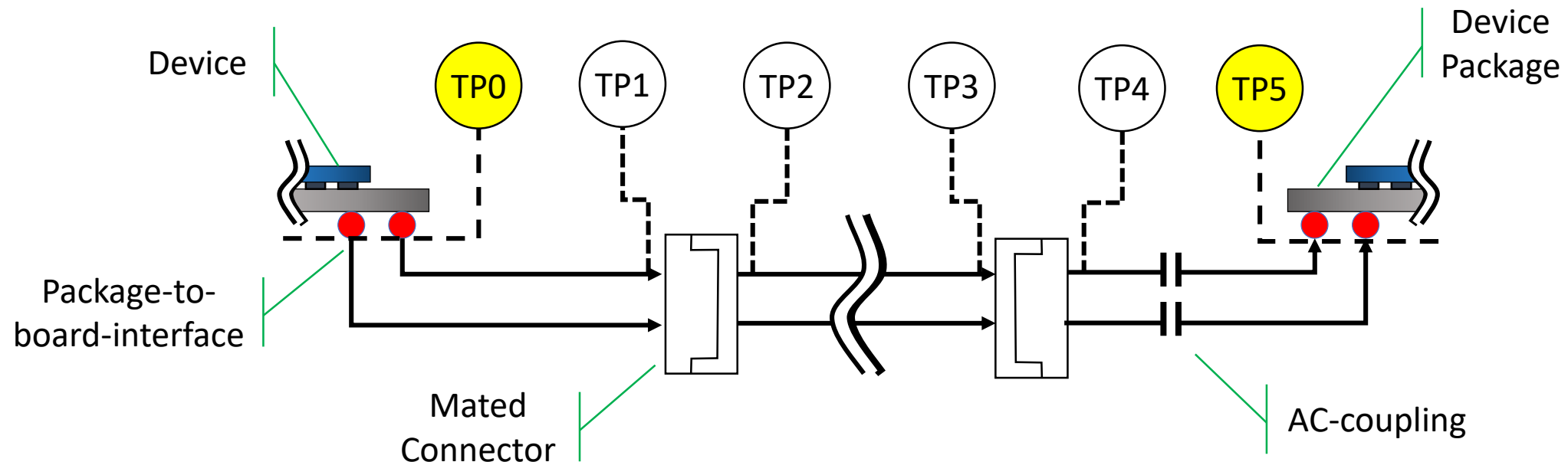


Basic Flow

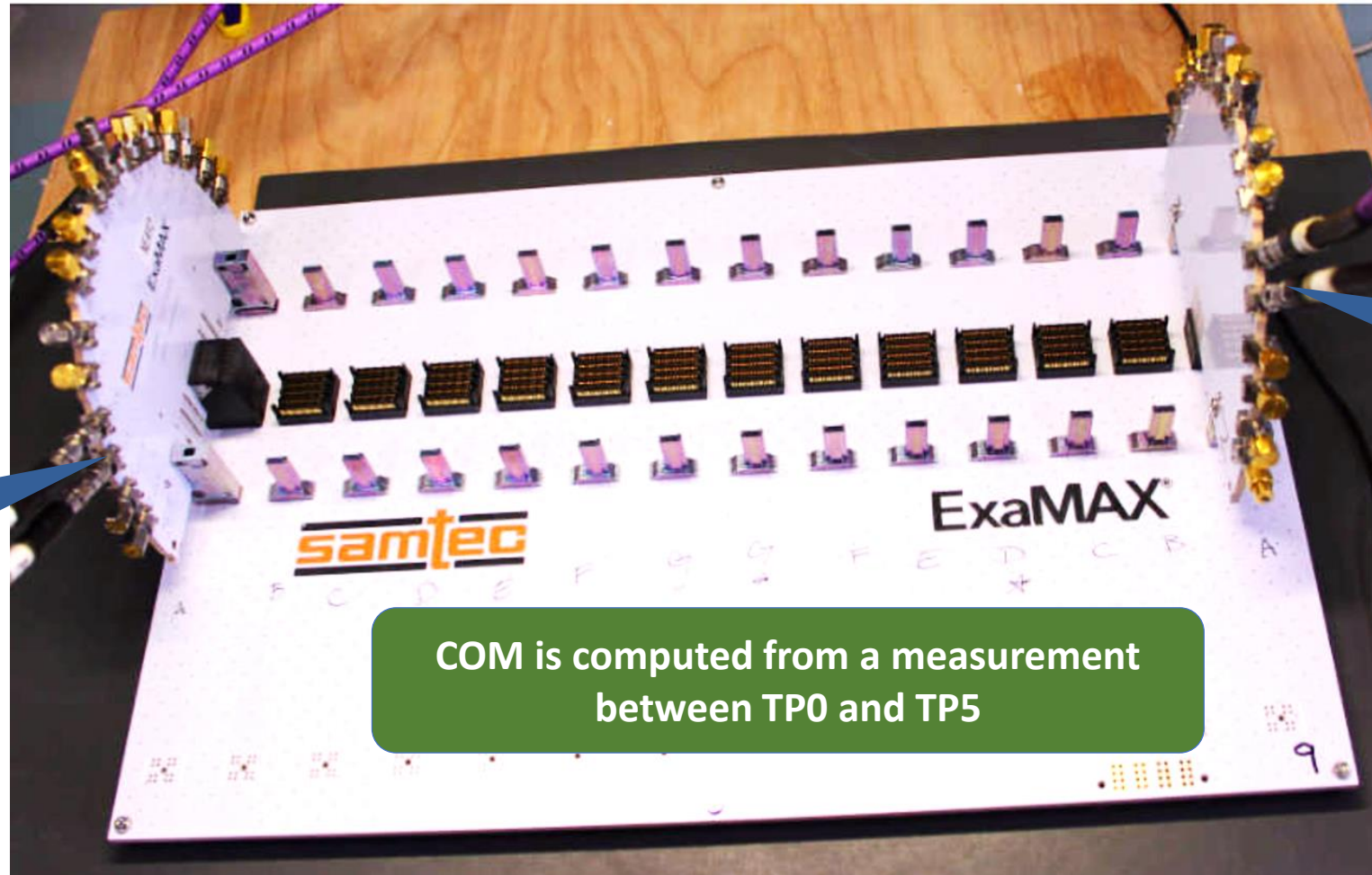


Channel Model

- COM is computed from differential scattering parameters between tp0 and tp5
 - This is essentially all the interconnect between two chips
- Reference Devices/Packages are mathematically added



Measuring a Channel to Compute COM



Assume
this is TP0

Assume
this is TP5

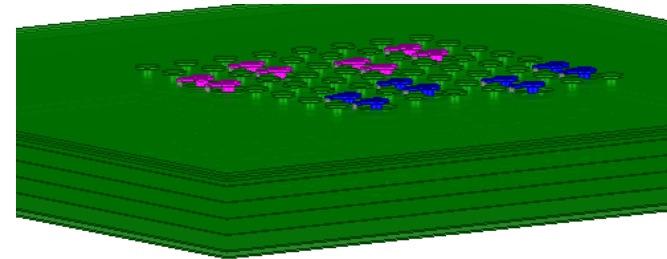
COM is computed from a measurement
between TP0 and TP5

Test Point (TP) Considerations



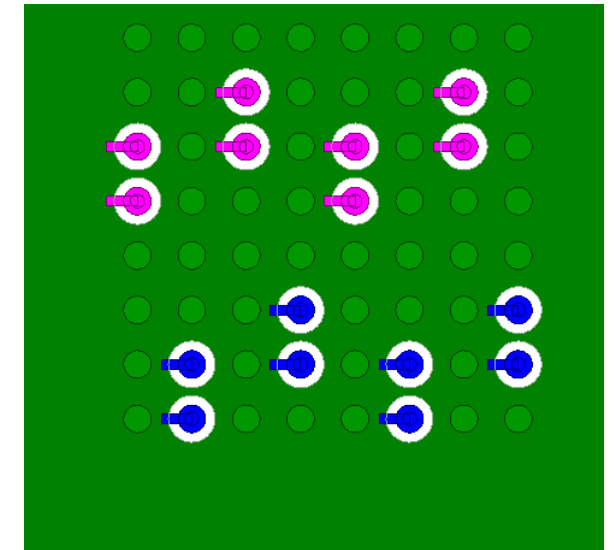
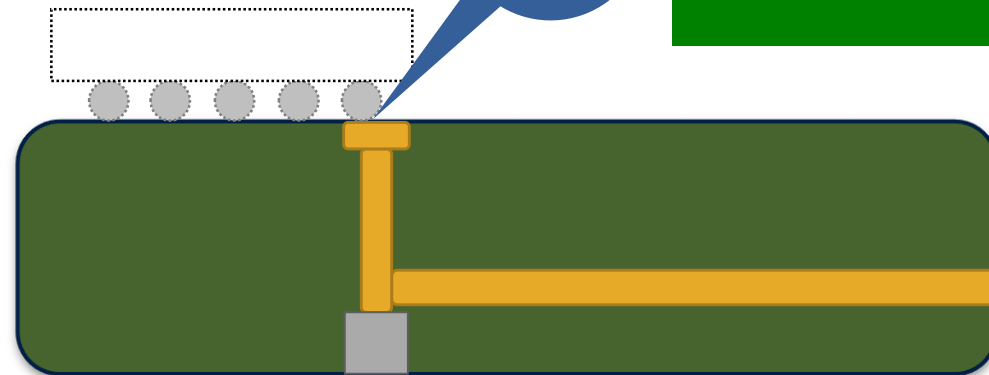
TP0

Instrumented Test Point



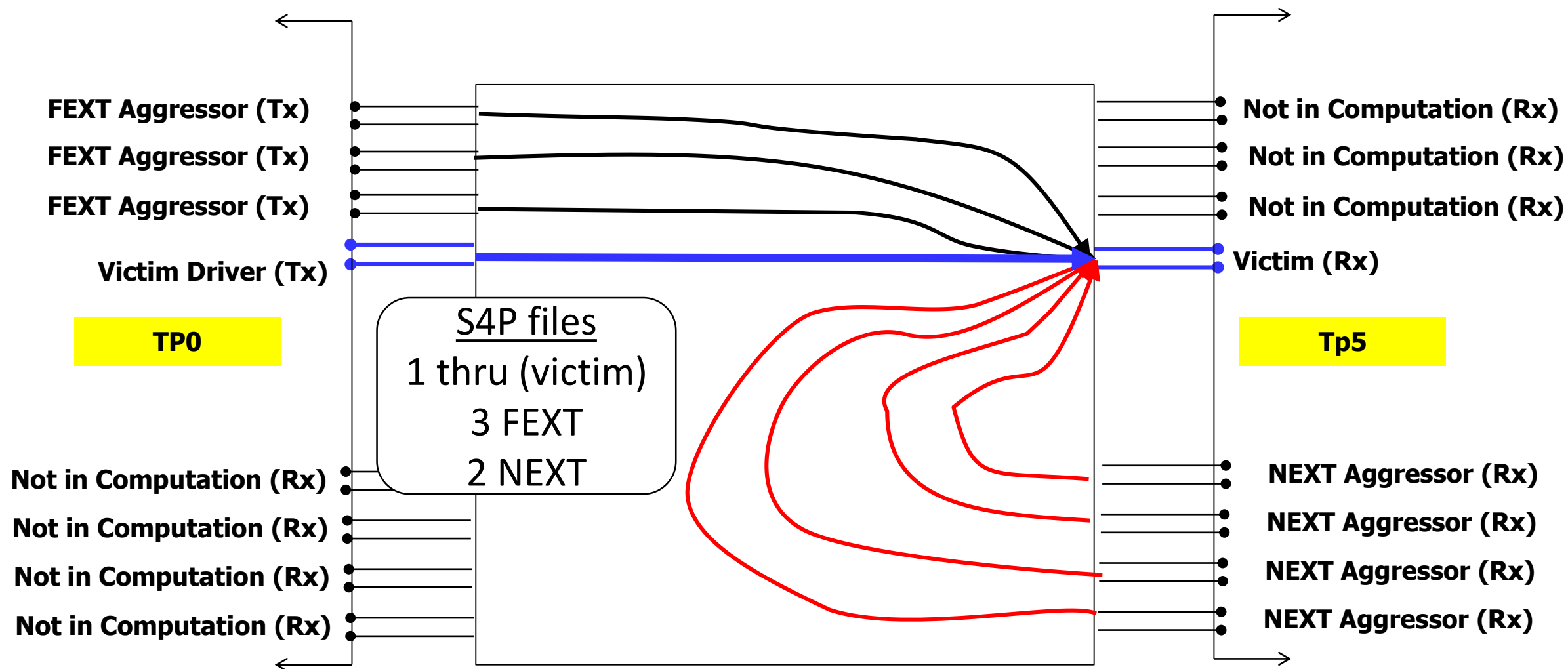
Product Test Point

TP0



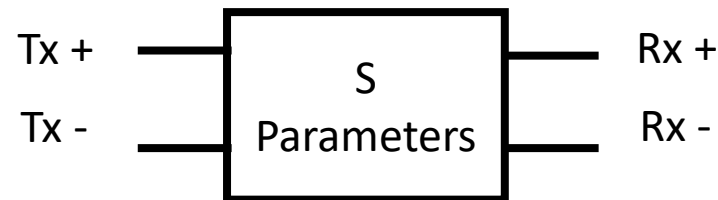
An Instrumented Test Point may be better than the Product Test Point

4-Lane Example Measurements



Basic S-parameter Script Requirements

- Range at least 10 MHz to the Baud rate ($2 \times$ Nyquist sampling frequency)
- S4p files are single ended
 - Reference to 50 ohms
- Minimum linear step size is 10 MHz
- 4-port S-parameters specified as [Tx+ Tx- Rx+ Rx-]
 - Default is [1 3 2 4]
 - Can specify in spread sheet: Example [1 2 3 4] or as required



General Configuration File Rules

- Only the tab “COM_Settings” is interpreted and used in the COM script
 - .XLS and .XLSX files are permitted
 - All other tabs are ignored and can be used for documentation
- Cells in the configuration file use a keyword/value syntax
- Keywords are text and to the right is a value
 - These two cells are a keyword pairs
 - Keyword pairs are position insensitive
 - Keyword syntax must be exact
 - All other syntax is treated as comments and ignored
 - The values are usually interpreted as Matlab expressions
- Many of the keywords are parameters, specified in channel standards
- Other keywords are operational control

c(-1)	[-0.34:0.02:0]
c(-2)	[0:0.02:0.12]
c(-3)	[-0.06:0.02:0]

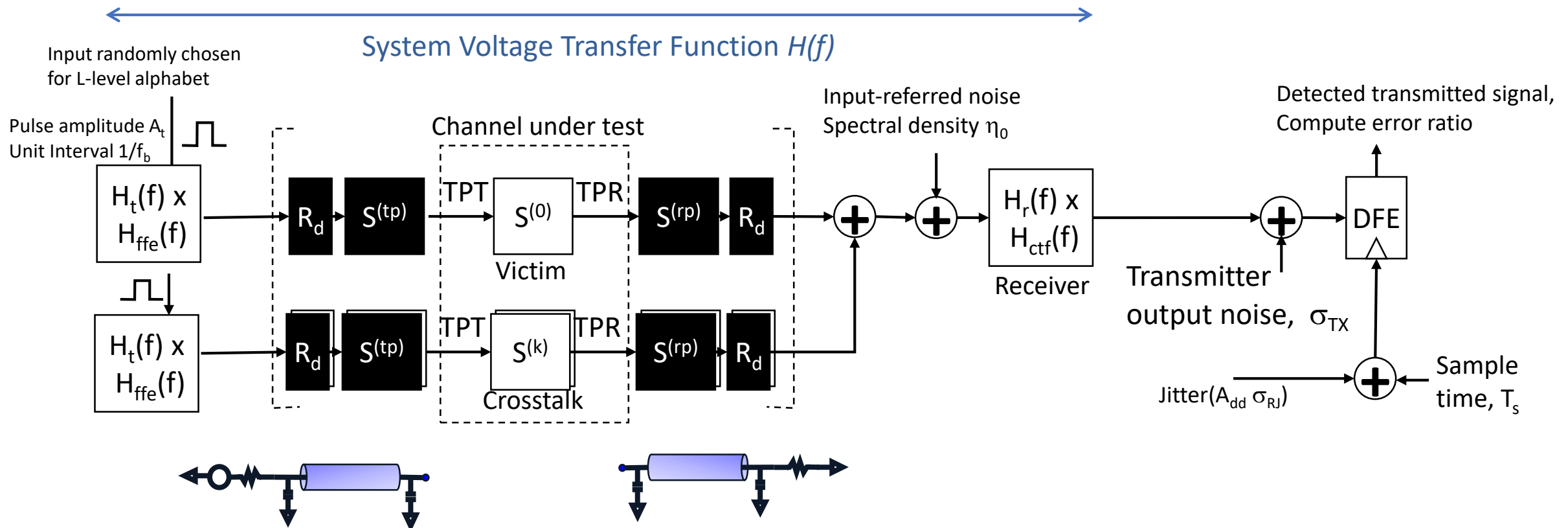
Parameter	Setting	Units	Information
f_b	25.78125	GBd	

Value

Keyword

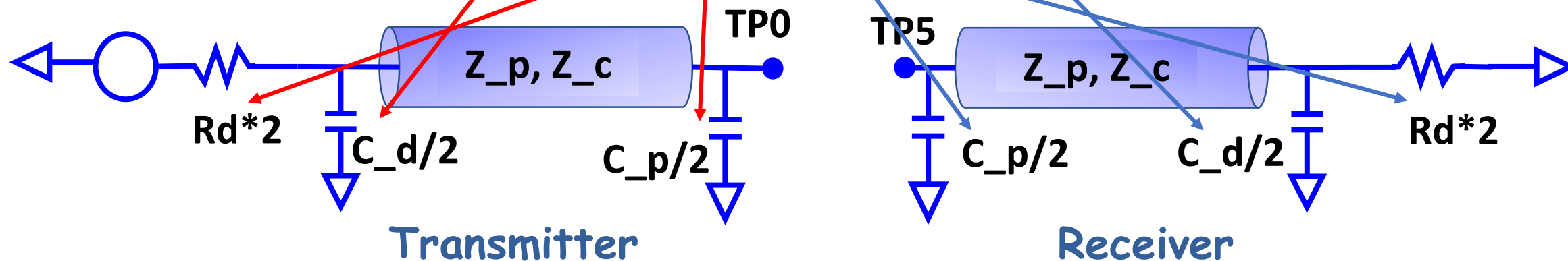
COM uses Differential S-parameters for Computation

- 4-port s4p channel files are converted into 2-port differential S-parameters
- Packages are cascaded in differential mode



The Simple Package used for under 56 Gbps

C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]

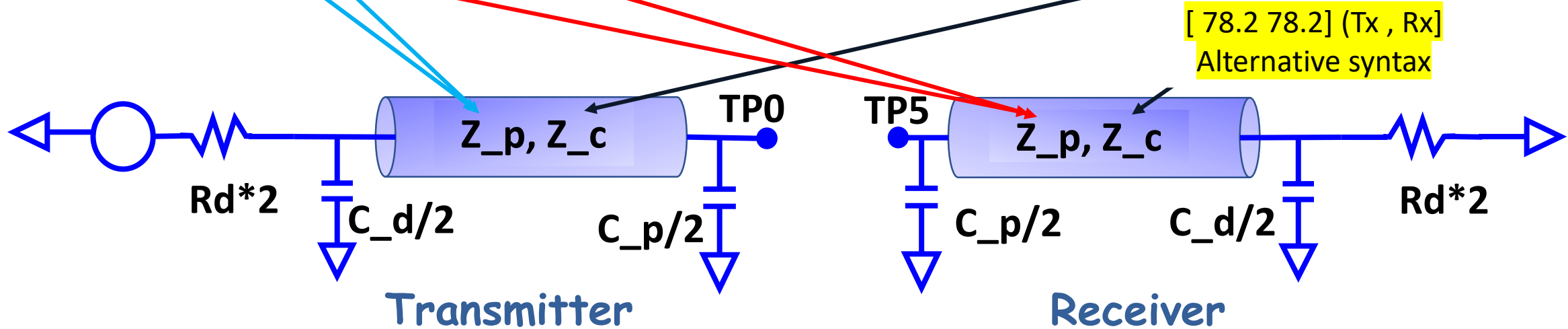


Die load (R_d , C_d) and package BGA ball/package vertical routing (C_p) are specified in the configuration file

The Simple Package used for under 56 Gbps: Routing

C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]

Table 93A–2 parameters		
Parameter	Setting	Units
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_Z_c	78.2	Ohm



Differential package transmission line length and impedance (Z_p, Z_c) are specified in the configuration file.
 Z_p and Z_c syntax is different

Test Cases

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	25.78125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]

Table 93A-2 parameters		
Parameter	Setting	Units
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_Z_c	78.2	Ohm

- COM runs once for each specified “z_p_select”
- z_p(TX), z_p(NEXT) , z_p(FEXT) , z_p(RX) are length index sections for z_p_select
- If “z_p_select” is only specified as 2, then COM only runs with the z_p(TX), z_p(NEXT), z_p(FEXT) , z_p(RX) and 30,12,30, 30 mm
- “z_p_select” as [2 1] is also valid syntax

Configuration Spreadsheet

- First example is 100 G Base KR4 example
- 25 Gb/s lane (NRZ)

25 Gbps (NRZ) Configuration Example

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	25.78125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.62		min
c(-1)	[-0.18:0.02:0]		[min:step:max]
c(1)	[-0.38:0.02:0]		[min:step:max]
g_DC	[-13:1:0]	dB	[min:step:max]
f_z	6.4453125	GHz	
f_p1	6.4453125	GHz	
f_p2	25.78125	GHz	
A_v	0.43	V	
A_fe	0.63	V	
A_ne	0.63	V	
L	2		
M	32		
N_b	14	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0.01	UI	
A_DD	0.05	UI	
eta_0	5.20E-08	V ² /GHz	
SNR_TX	27	dB	
R_LM	1		
DER_0	1.00E-05		
Operational control			
COM Pass threshold	3	dB	
Include PCB	0	logical	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
SAVE_FIGURE_to_CSV	0	logical
RESULT_DIR	.\results\KR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	1.20E-02	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical

Table 93A-2 parameters		
Parameter	Setting	Units
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	1.734e-3 1.455e-4]	
package_Z_c	78.2	Ohm
Table 92-12 parameters		
Parameter	Setting	Units
board_tl_tau	6.191E-03	ns
board_tl_gamma0_a1_a2	4.114e-4 2.547e-4]	
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

Start with Entering the COM Script Name at Matlab® Prompt

Command Window

```
>> com_ieee8023_93a_310  
This is NOT an official IEEE document.  
Revision: 3.10 This is a computation example for exploring COM and ERL  
for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official  
fx Enter config XLS file or return will just pop a window to ask for the XLS file]: config_com_ieee8023_93a=25GBASE-KR.xls
```

That Starts COM Running Interactively

>> com_ieee8023_93a_310

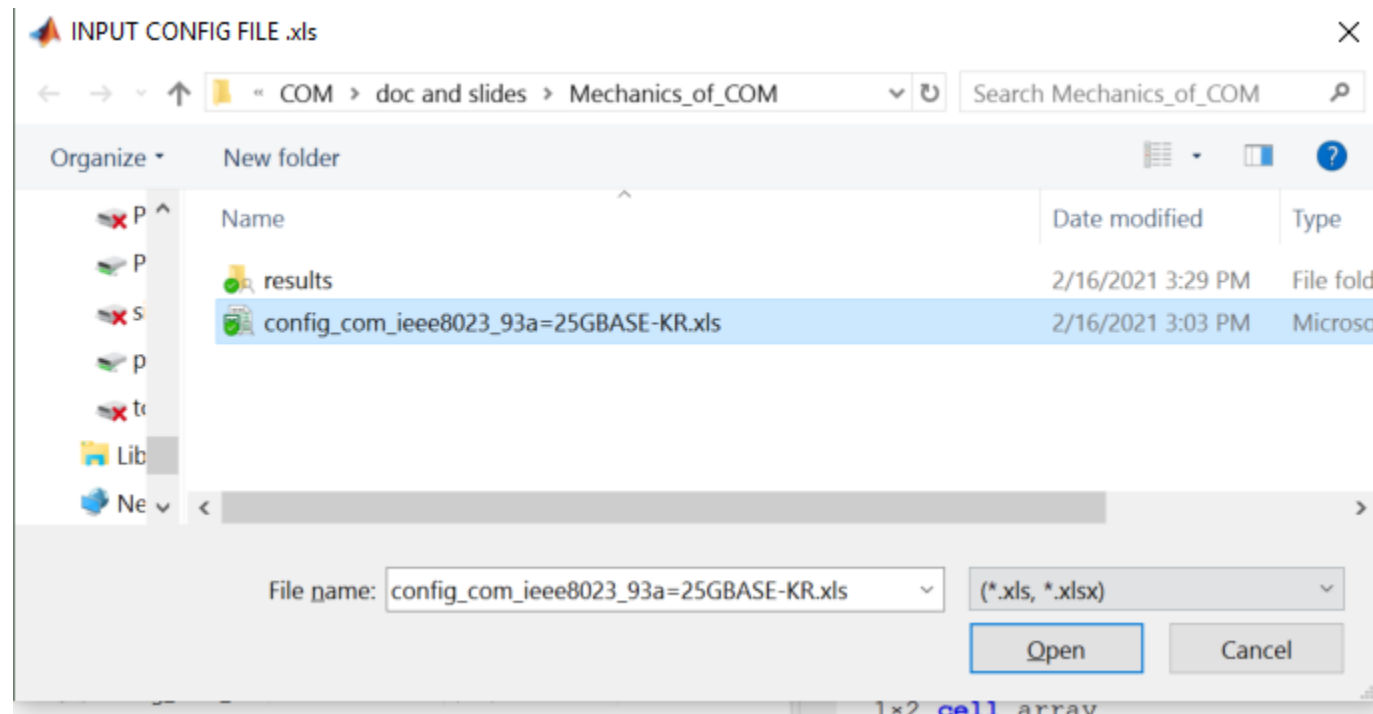
This is NOT an official IEEE document

Revision: 3.10 This is a computation example for exploring COM and ERL

for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official

Enter config XLS file or return will just pop a window to ask for the XLS file]: config_com_ieee8023_93a=25GBASE-KR.xls

Now enter the configuration file name or alternatively just return to select



Running COM Interactively: Channels

>> **com_ieee8023_93a_310**

This is NOT an official IEEE document

Revision: 3.10 This is a computation example for

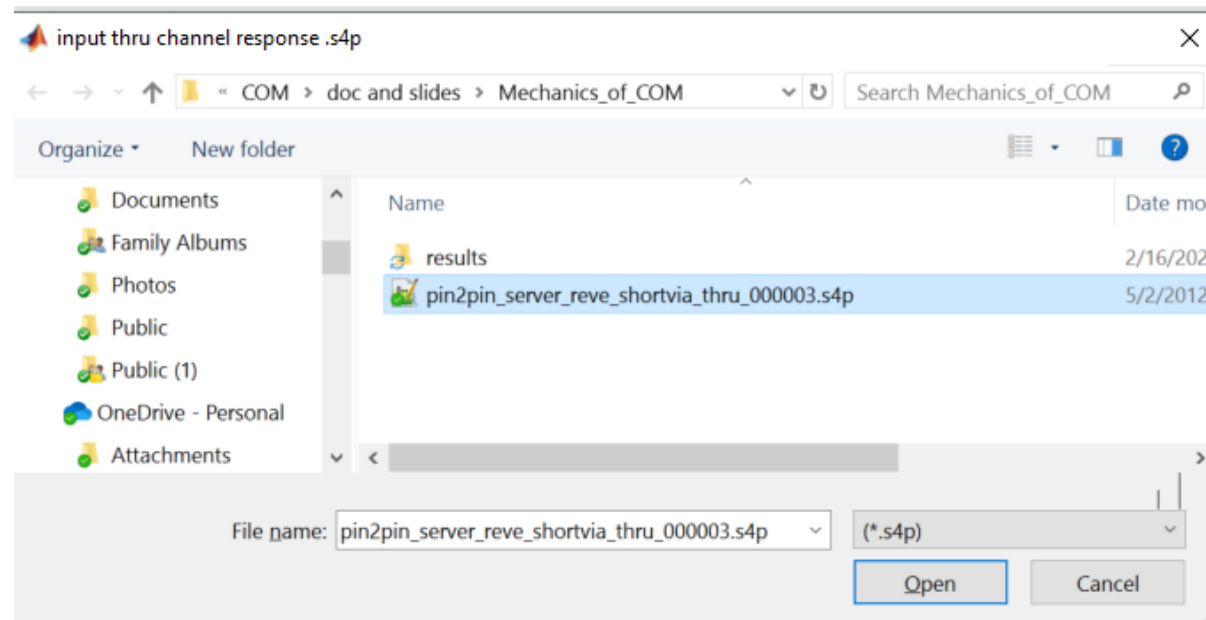
for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official

Enter config XLS file or return will just pop a window to ask for the XLS file]: config_com_ieee8023_93a=25GBASE-KR.xls

How many FEXT channels are to be entered? [return means no FEXT]

How many NEXT channels are to be entered? [return means no NEXT]

Our first example will not include crosstalk
Just hit return for NEXT and FEXT



Running COM Interactively: Screen Output

>> **com_ieee8023_93a_310**

This is NOT an official IEEE document

Revision: 3.10 This is a computation example for exploring COM and ERL

for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official

Enter config XLS file or return will just pop a window to ask for the XLS file]: config_com_ieee8023_93a=25GBASE-KR.xls

How many FEXT channels are to be entered? [return means no FEXT]

How many NEXT channels are to be entered? [return means no NEXT]

KR_ --pin2pin_server_reve_shortvia_thru_000003

KR_ --pin2pin_server_reve_shortvia_thru_000003

FOM: 13 dB

TXFFE coefficients: [-0.18 0.62 -0.2]

SNR ISI: 21 dB

CTLE DC gain: -13 dB

CTF peaking gain: -2 dB

Symbol Available signal: 0.007997

run time = 0.698398 min

Causality correction = -46.1 dB (not applied)

Truncation ratio = -48.6 dB

Figure or merit result for
optimization
Signal/(rms noise)

Pulse peak/ISI noise
Not valid without special spreadsheet

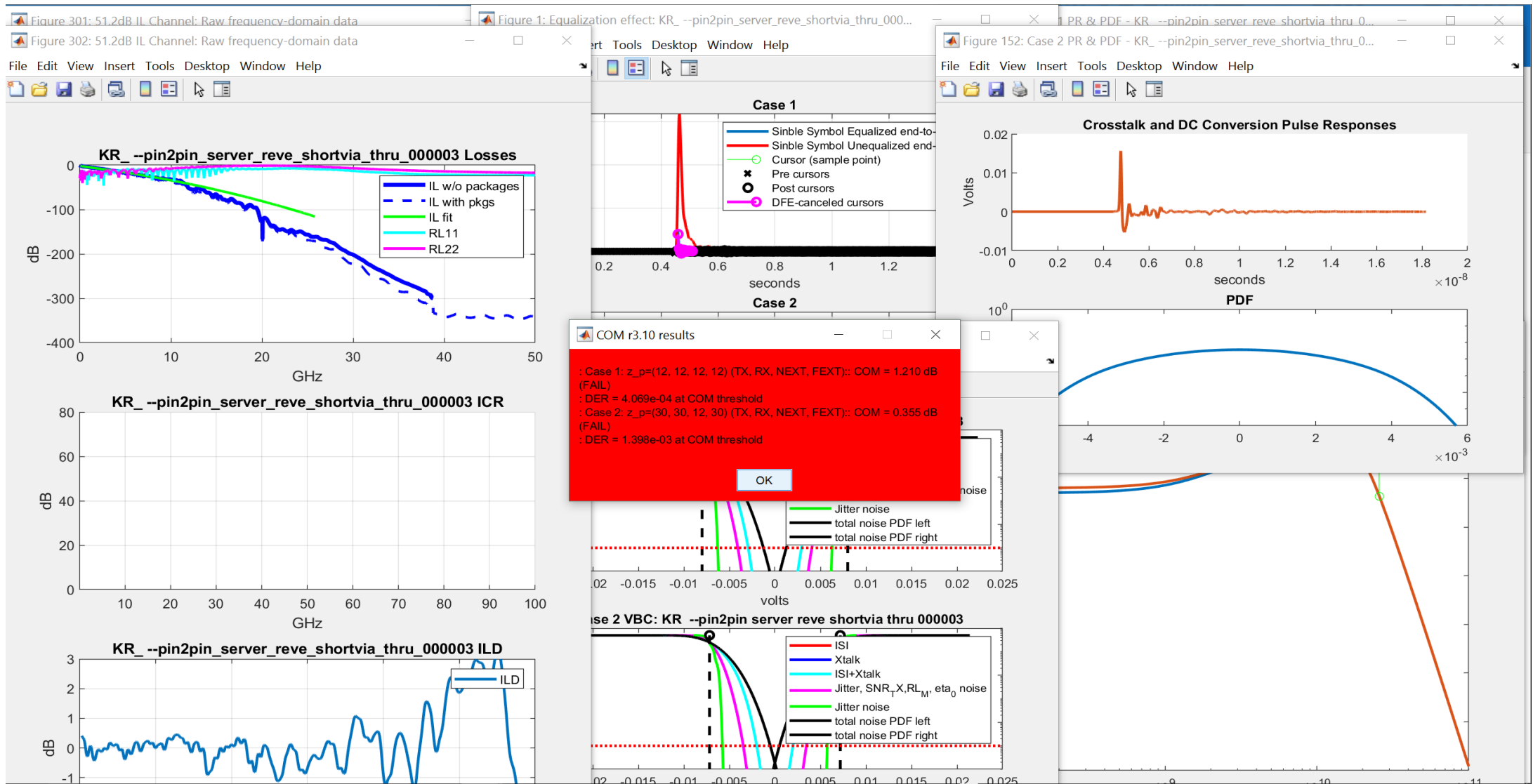
Voltage value of the symbol pulse response at the sample point

Run time

Quality assessment of
s-parameters
Should < -30 dB for thru
channel not as good a
metric for crosstalk

COM assumes good s-parameters

Running COM Interactively: Many Results Windows



Displayed Outputs (Also as Parameters)

--- Testcase 1 results ---

```
code_revision: '3.10'
  RL: [1x1 struct]
  RxFFE: ''
  RxFFEgain: ''
config_file: 'config_com_ieee8023_93a=25GBASE-KR.xls'
file_names: '"KR_ --pin2pin_server_reve_shortvia_th
  R_diepad: [55 55]
  C_diepad: [2.5000e-13 2.5000e-13]
  L_comp: [0 0]
  C_bump: 0
  levels: 2
  Pkg_len_TX: 12
  Pkg_len_NEXT: 12
  Pkg_len_FEXT: 12
  Pkg_len_RX: 12
  pkg_Z_c: [78.2000 78.2000]
  C_v: [0 0]
baud_rate_GHz: 25.7813
f_Nyquist_GHz: 12.8906
  BER: 1.0000e-05
  FOM: 13.0297
  sigma_N: 7.0693e-04
  DFE4_RSS: 0.1880
  DFE2_RSS: 0.2454
  tail_RSS: 0
channel_operating_margin_dB: 1.2096
available_signal_after_eq_mV: 7.9970
  peak_uneq_pulse_mV: 63.4269
  uneq_FIR_peak_time: 4.5794e-09
steady_state_voltage_mV: 324.6584
  FOM_ILD: 3.8935

Peak_ISI_XTK_and_Noise_interference_at_BER_mV: 6.9574
peak_ISI_XTK_interference_at_BER_mV: 5.2061
peak_ISI_interference_at_BER_mV: 5.2061
equivalent_ICI_sigma_assuming_PDF_is_Gaussian_mV: 1.2207
peak_MDXTK_interference_at_BER_mV: 0
peak_MDNEXT_interference_at_BER_mV: 0
peak_MDFEXT_interference_at_BER_mV: 0
  ICN_mV: 0
  MDNEXT_ICN_92_46_mV: 0
  MDFEXT_ICN_92_47_mV: 0
equivalent_ICN_assuming_PDF_is_Gaussian_mV: 0
  SNR_ISI_XTK_normalized_1_sigma: 16.3265
  SNR_ISI_est: 20.5719
  Pmax_by_Vf_est: 0.1954
  CTLE_zero_poles: [6.4453e+09 2.5781e+10 6.4453e+09]
  CTLE_DC_gain_dB: -13
  TXLE_taps: [-0.1800 0.6200 -0.2000]
  Pre2Pmax: 0.2903
  DFE_taps: [14x1 double]
sgm_Ani__isi_xt_noise: 0.0018
sgm_isi_xt: 0.0015
sgm_isi: 0.0015
sgm_xt: 0
sgm_noise__gaussian_noise_p_DD: 9.9442e-04
sgm_p_DD: 5.8972e-04
sgm_gaussian_noise: 8.0068e-04
sgm_G: 8.0083e-04
sgm_rjit: 1.1824e-04
sgm_N: 7.0693e-04
sgm_TX: 3.5721e-04
total_IL_wpkgs_dB_at_Fnq: 56.1033
IL_dB_channel_only_at_Fnq: 51.1904
fitted_IL_dB_at_Fnq: 46.3054
  VEC_dB: 17.7211
  VEO_mV: 2.0792
  EW_UI_est: 0.2500
  eye_contour: [100x2 double]
  VEO_window_mUI: 0
  COM_dB: 1.2096
  DER_thresh: 4.0688e-04
  rtmin: 0.6984
```

Run without Display Windows Decreases Run-time

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical

} Use these two together

```
>> com_ieee8023_93a_310
This is NOT an official IEEE document
Revision: 3.10 This is a computation example for exploring COM and ERL
  for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official
Enter config XLS file or return will just pop a window to ask for the XLS file]:
How many FEXT channels are to be entered? [return means no FEXT]
How many NEXT channels are to be entered? [return means no NEXT]
reading file 1
reading file processing COM PDF FOM search10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
1
Case 1:  FAIL ... COM = 1.210 dB
Case 1: DER = 4.069e-04 at COM threshold
run time = 0.538324 min
--- Testcase 1 results ---

                                code_revision: '3.10'
                                RL: [1x1 struct]
                                RxFFE: ``
```

...

Command Line with FEXT and NEXT

```
com_ieee8023_93a_310('config_com_ieee8023_93a=3ck_d1p4_KR_01_11_21.xlsx',2,1, ...  
    'CaBP_BGAVia_Opt2_28dB_THRU.s4p',...  
    'CaBP_BGAVia_Opt2_28dB_FEXT1.s4p','CaBP_BGAVia_Opt2_28dB_FEXT2.s4p',...  
    'CaBP_BGAVia_Opt2_28dB_NEXT1.s4p')
```

```
com_ieee8023_93a_310('config_com_ieee8023_93a=3ck_d1p4_KR_01_11_21.xlsx',2,1, ...  
    'CaBP_BGAVia_Opt2_28dB_THRU.s4p',...  
    'CaBP_BGAVia_Opt2_28dB_FEXT1.s4p','CaBP_BGAVia_Opt2_28dB_FEXT2.s4p',...  
    'CaBP_BGAVia_Opt2_28dB_NEXT1.s4p')
```

Command Line Format

```
>> com_ieee8023_93a_310('config_com_ieee8023_93a=25GBASE-KR.xls',0, 0, ...  
    'pin2pin_server_reve_shortvia_thru_000003.s4p')
```

Syntax:

com_ieee8023_93a_310({configuration file}, {number of FEXT files}, { number of NEXT files, {through file},
{FEXT file 1}, ... {FEXT file n}, {NEXT file 1}, ... {NEXT file M})

{configuration file} string: .xls, .xlsx, .mat configuration file name

{number of FEXT files} integer: number of FEXT files

{number of NEXT files} integer: number of NEXT files

{through file} string: victim channel files (.s4p)

{FEXT file 1}, ... {FEXT file n} **comma separated strings: FEXT channel files (.s4p)**

{NEXT file 1}, ... {NEXT file n} comma separated strings: NEXT channel files (.s4p)

All s4p files must have the same frequency points and port assignments

PAM4 was Introduced First for 25Gbps called 100G BASE-KP4

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	13.59375	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[2.5e-4 2.5e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	[TX RX]
R_o	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.62		min
c(-1)	[-0.18:0.02:0]		[min:step:max]
c(1)	[-0.38:0.02:0]		[min:step:max]
g_DC	[-12:1:0]	dB	[min:step:max]
f_z	3.3984375	GHz	
f_p1	3.3984375	GHz	
f_p2	13.59375	GHz	
A_v	0.4	V	
A_fe	0.4	V	
A_ne	0.6	V	
L	4		
M	32		
N_b	16	UI	
b_max(1)	1		
b_max(2..N_b)	0.2		
sigma_RJ	0.005	UI	
A_DD	0.025	UI	
eta_o	5.20E-08	V^2/GHz	
SNR_TX	31	dB	
R_LM	0.92		
DER_o	3.00E-04		
Operational control			
COM Pass threshold	3	dB	
Include PCB	0	logical	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	0	logical
Display frequency domain	1	logical
CSV_REPORT	0	logical
SAVE_FIGURE_to_CSV	0	logical
RESULT_DIR	.\results\KP4_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	8.00E-03	ns
Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	0	logical
INCLUDE_CTLE	1	logical
INCLUDE_TX_RX_FILTER	1	logical

Table 93A-2 parameters		
Parameter	Setting	Units
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_Z_c	78.2	Ohm

Table 92-12 parameters		
Parameter	Setting	Units
board_tl_tau	6.191E-03	ns
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm

25Gbps PAM 2 and PAM 4

```
com_ieee8023_93a_310('config_com_ieee8023_93a=25GBASE-  
KR.xls',0,0,'pin2pin_server_reve_shortvia_thru_000003.s4p')
```

COM r3.10 results

: Case 1: z_p=(12, 12, 12, 12) (TX, RX, NEXT, FEXT):: COM = 1.210 dB (FAIL)
: DER = 4.069e-04 at COM threshold
: Case 2: z_p=(30, 30, 12, 30) (TX, RX, NEXT, FEXT):: COM = 0.355 dB (FAIL)
: DER = 1.398e-03 at COM threshold

25Gb/s PAM 2

OK

A_fe	0.63	V	
A_ne	0.63	V	
L	2		
M	32		
N_b	14	UI	

```
com_ieee8023_93a_310('config_com_ieee8023_93a=100GBASE-  
KP4.xls',0,0,'pin2pin_server_reve_shortvia_thru_000003.s4p')
```

COM r3.10 results

: Case 1: z_p=(12, 12, 12, 12) (TX, RX, NEXT, FEXT):: COM = 4.034 dB (pass)
: DER = 4.808e-05 at COM threshold
: Case 2: z_p=(30, 30, 12, 30) (TX, RX, NEXT, FEXT):: COM = 3.103 dB (pass)
: DER = 2.578e-04 at COM threshold

OK

25Gb/s PAM 4

A_fe	0.4	V	
A_ne	0.6	V	
L	4		
M	32		
N_b	14	UI	

PAM is specified as the keyword “L”, 2 is NRZ, 4 is for PAM4. Any PAM level “L” may be used. In the above 2 “Test Cases” were run.

Assign results to a structure in the command line

`My_results =`

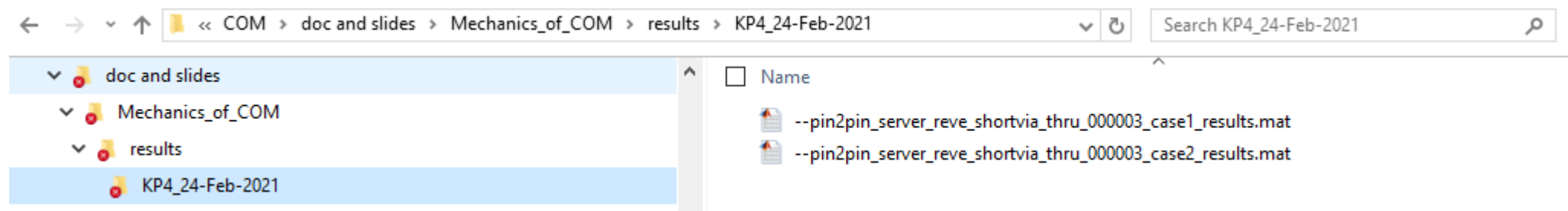
```
com_ieee8023_93a_310('config_com_ieee8023_93a=3ck_dlp4_KR_01_11_21.xlsx',2,1, ...  
    'CaBP_BGAVia_Opt2_28dB_THRU.s4p',...  
    'CaBP_BGAVia_Opt2_28dB_FEXT1.s4p','CaBP_BGAVia_Opt2_28dB_FEXT2.s4p',...  
    'CaBP_BGAVia_Opt2_28dB_NEXT1.s4p')
```

The image displays the MATLAB interface with the following components:

- Variables - My_results(1, 2):** A table showing the structure `My_results` with 6 columns (1-6) and 3 rows. The first row contains two `1x1 struct` objects.
- My_results(1, 2):** A table showing the fields of the structure. The fields are: `code_revision` (value: '3.10'), `RL` (value: `1x1 struct`), `Z11est` (value: 99.4799), `Z22est` (value: 99.4799), `ERL11` (value: 17.5688), `ERL22` (value: 17.5688), `ERL` (value: 17.5688), `RxFFE` (value: ''), `RxFFEgain` (value: ''), `config_file` (value: 'config_com_ieee8023_93'), and `file_names` (value: 'KR_eval_--CaBP_BGAVi').
- Workspace:** A table showing the variable `My_results` with a value of `1x2 cell`.
- Command Window:** Displays the output of the command, including SNR ISI (38 dB), CTLE DC gain (-12 dB), CTF peaking gain (-3.1 dB), Symbol Available signal (0.0034208), run time (6.20678 min), and WC All cases (PASS ... COM = 4.959 dB, DER = 4.881e-07 at COM threshold, ERL = 17.569 dB).

Output Control in the Configuration Spreadsheet

DIAGNOSTICS	1 or 0	If set to 1 will cause the outputs to be recorded in a .mat file. Also a few more parameters are recorded
DISPLAY_WINDOW	1 or 0	Turns on (1) and off (0) graphic and display window
CSV_REPORT	1 or 0	If set to 1 will cause the outputs to be recorded in a .CSV file. This contains the same data as in the .mat file
SAVE_FIGURES	1 or 0	If set to and DISPLAY_WINDOW is 1 the graphic figures are saved as .fig files in the results directory
SAVE_FIGURE_to_CSV	1 or 0	Not recommended set to 0
RESULT_DIR	.\result\KP4_{date}	A directory specification for where the reports and figure files are written. There is an optional syntax where the date is preplaced with the "{date}" string.



Transition Time Syntax Caveats in Early Spreadsheets

- Later version of COM uses “FORCE_TR” to enable the transition time filter
- The default if not specified is 1. The associated Gaussian 20%-80% transition time is keyword “T_R”.
 - The unit are nano-seconds
 - Setting T_r_filter_type to 1, T_r_meas_point to 0, and IDEAL_TX_TERM to 0 is the equivalent of setting FORCE_TR to 1. This a quirk for backwards compatibility
- In general, the way IEEE specifies units in the following:
 - if giga is used for frequency, nano is used in other units. I.e. C_d is specified as nF not F or pF.
- Sometime the units are in terms for the baud rate f_b. The spreadsheet typically annotates what units are required for the respective keyword.
 - Units must be specified exactly as required

100 Gbps PAM4 Example Spreadsheet

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 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 29; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.413	V	
A_fe	0.413	V	
A_ne	0.608	V	
AC_CM_RMS	0	V	[test cases]
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	[-0.34:0.02:0]		[min:step:max]
c(-2)	[0:0.02:0.12]		[min:step:max]
c(-3)	[-0.06:0.02: 0]		[min:step:max]
c(1)	[-0.2:0.05:0]		[min:step:max]
N_b	12	UI	
b_max(1)	0.85		
b_max(2..N_b)	[0.3 0.2*ones(1,10)]		
b_min(1)	0.3		
b_min(2..N_b)	[0.05 -0.03*ones(1,10)]		
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	21.25	GHz	
f_p1	21.25	GHz	
f_p2	53.125	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	

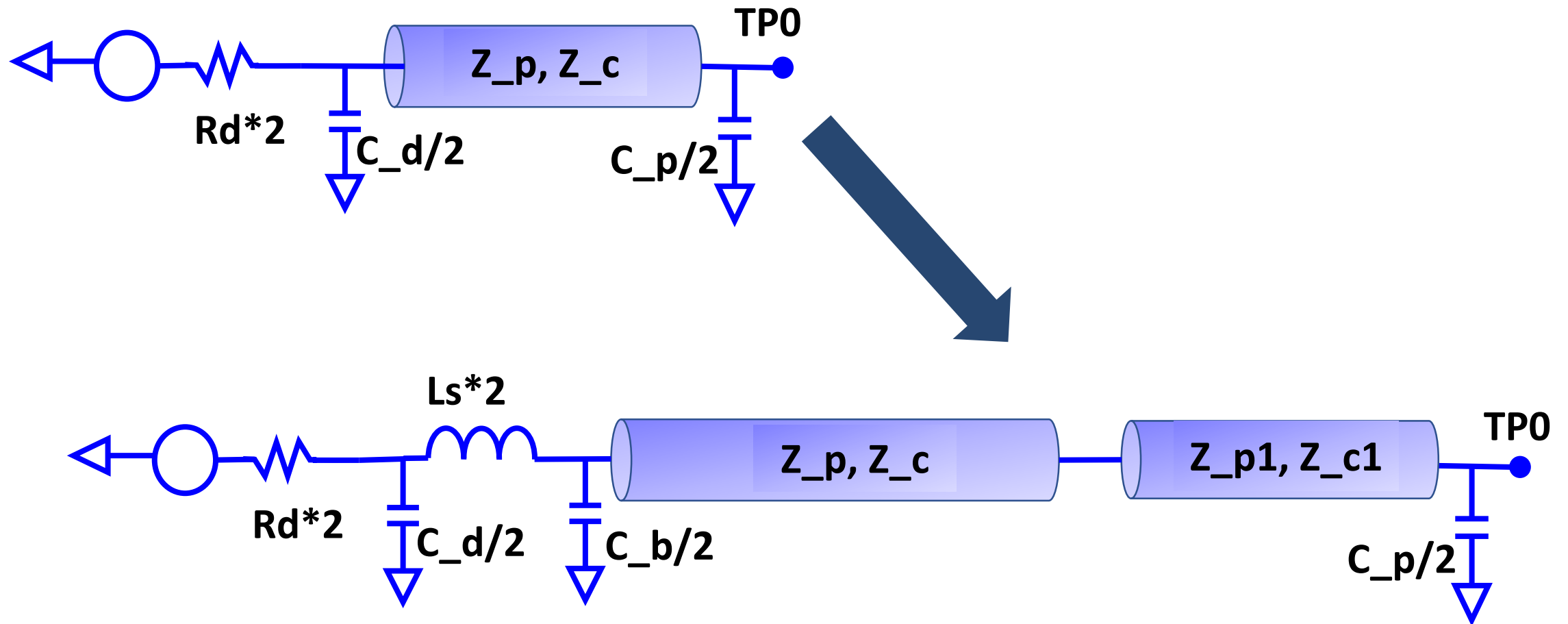
I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	0.0001	
T_r	0.0075	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
PLOT_CM	0	
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3500	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

Table 93A-3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
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)	110.3	mm
z_bp (NEXT)	110.3	mm
z_bp (FEXT)	110.3	mm
z_bp (RX)	110.3	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	0	logical
Floating Tap Control		
N_bg	3	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN & FOM_ILD parameters		
f_v	0.594	*Fb
f_f	0.594	*Fb
f_n	0.594	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	0.600	V
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V

Between Version of COM

- Spreadsheets are backward compatible
 - New parameter defaults are intended to have no effect on COM, if not specified
- Big changes for 100 Gbps
 - More robust reference package model (covered in presentation)
 - Floating taps
 - Additional pole zero pair for continuous time filters
 - Effective return loss (ERL) and TDR
 - Started with 50 Gbps PAM4
 - Separate parameter for FOM_ILD and ICN
 - Maximum and minimum DFE tap limits separated
 - AC RMS mode conversion

100 Gbps Reference Package Created Syntax Challenges



2 Segment with T-coil Emulation Package

Model Syntax needs to be Precise and Exact

C_d	[1.2e-4 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 29; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]

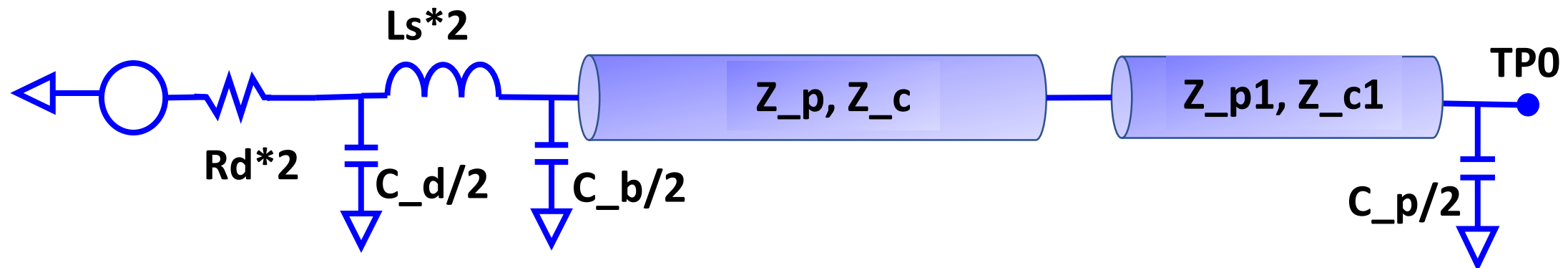
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

z_p (TX) [Z_p(case 1) Z_p(case 2)]

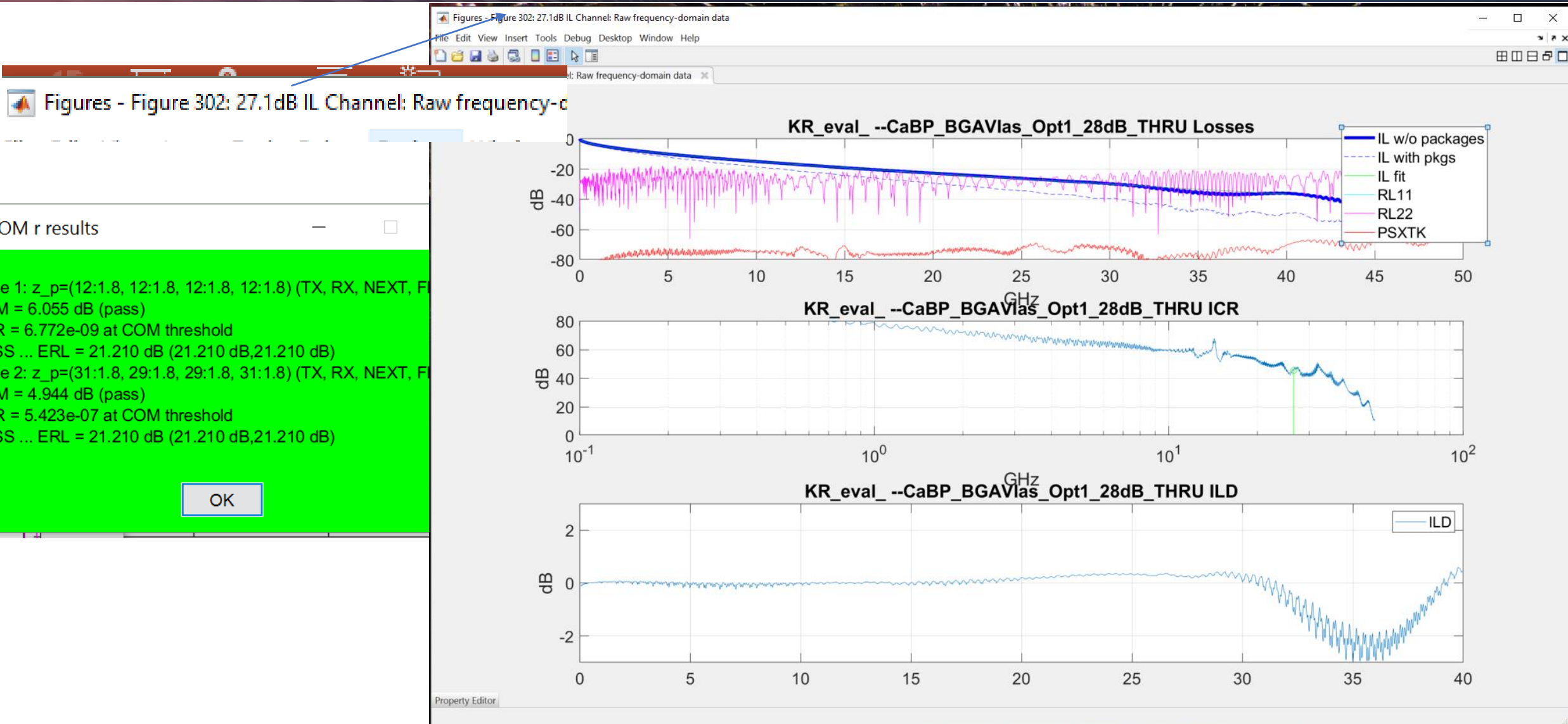
package_Z_c Z_c (Tx and Rx)]

package_Z_c [Z_c (Tx) Z_c(Rx) ; Z_c1(Tx) Z_c1(Rx)]

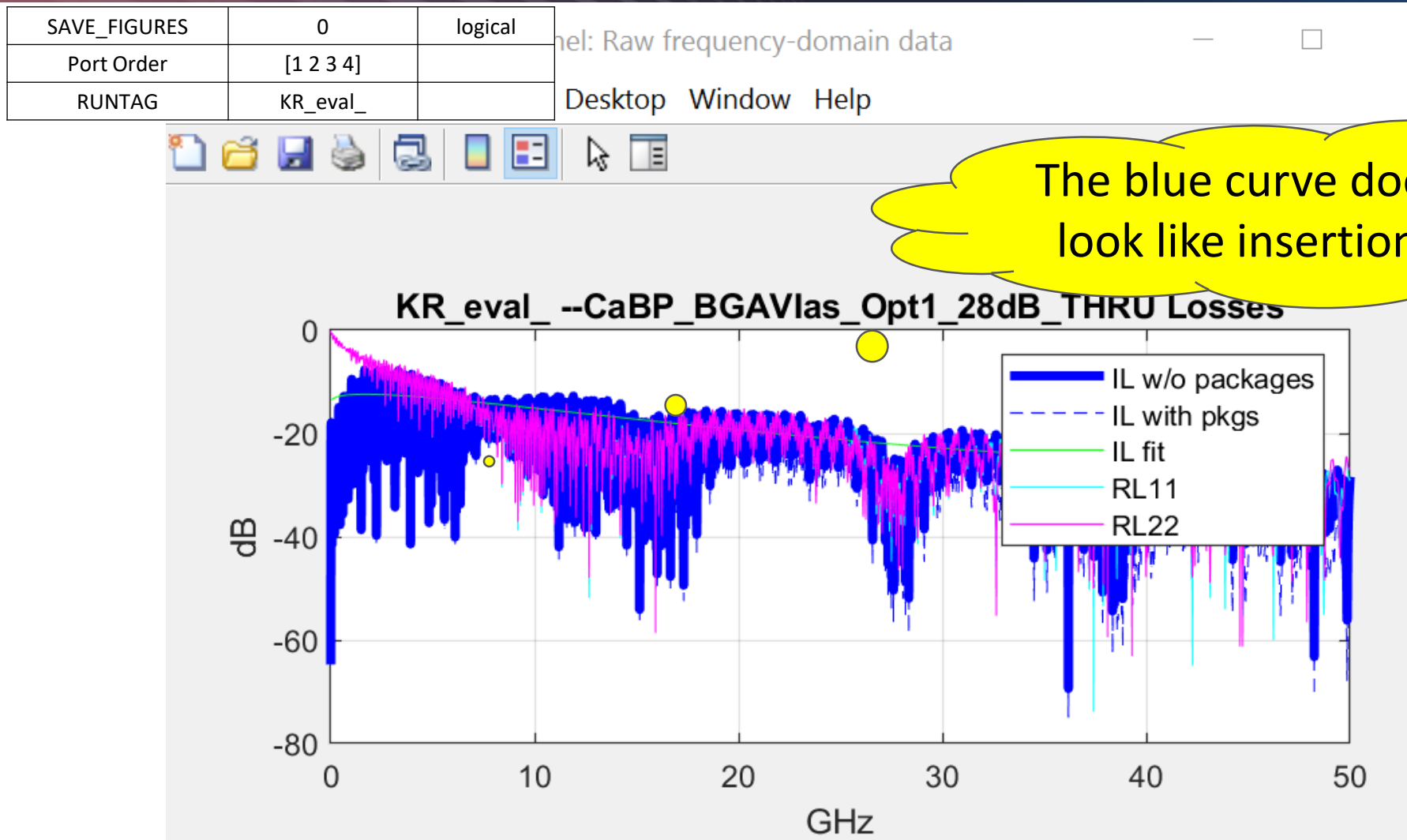
z_p select	[1 2] cases
z_p (TX)	[Z_p (case 1) Z_p(case 2) ; Z_p1(case 1) Z_p1(case 2)]



Channel Frequency Plots



Most Common S4P Issues: Port Assignment



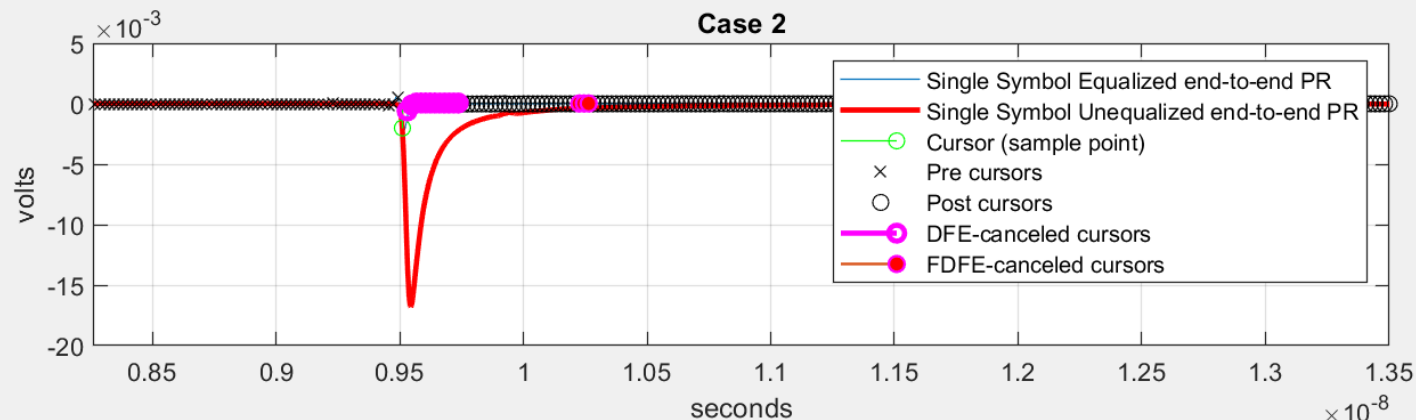
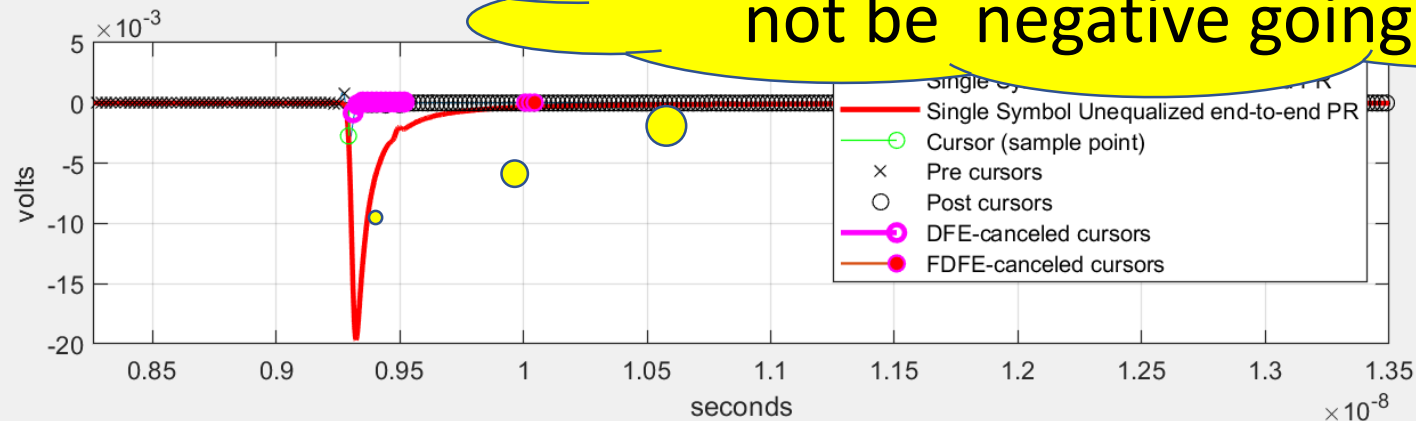
Another Common Port Problem: Plus Minus Reversed

SAVE_FIGURES	0	logical
Port Order	[3 1 2 4]	
RUNTAG	KR_eval_	

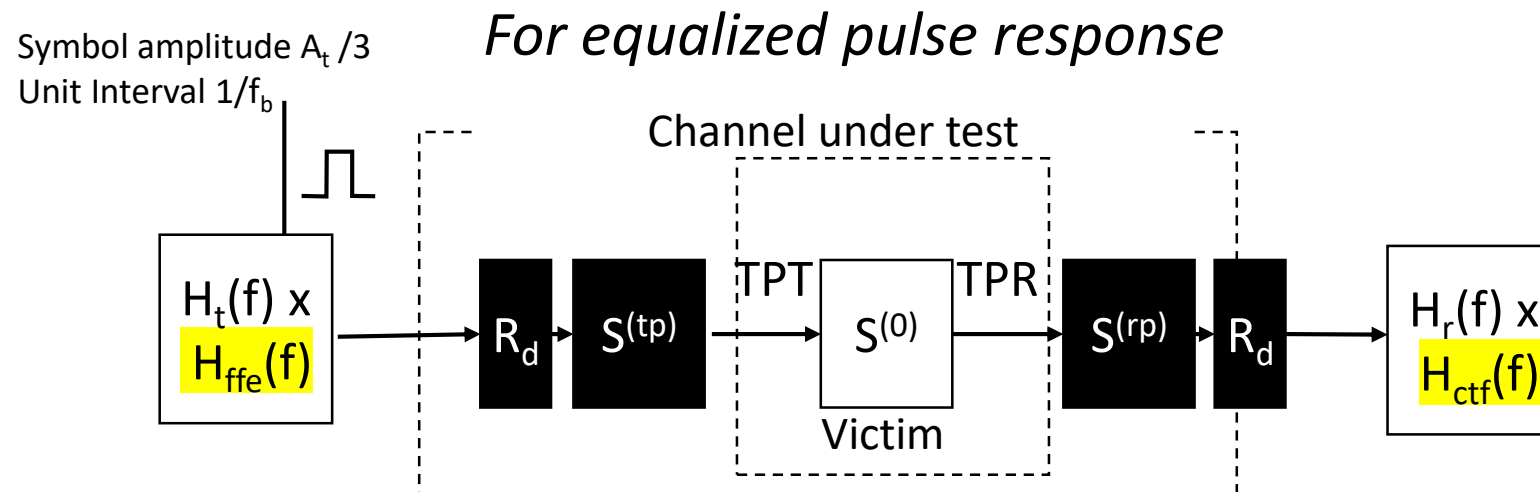
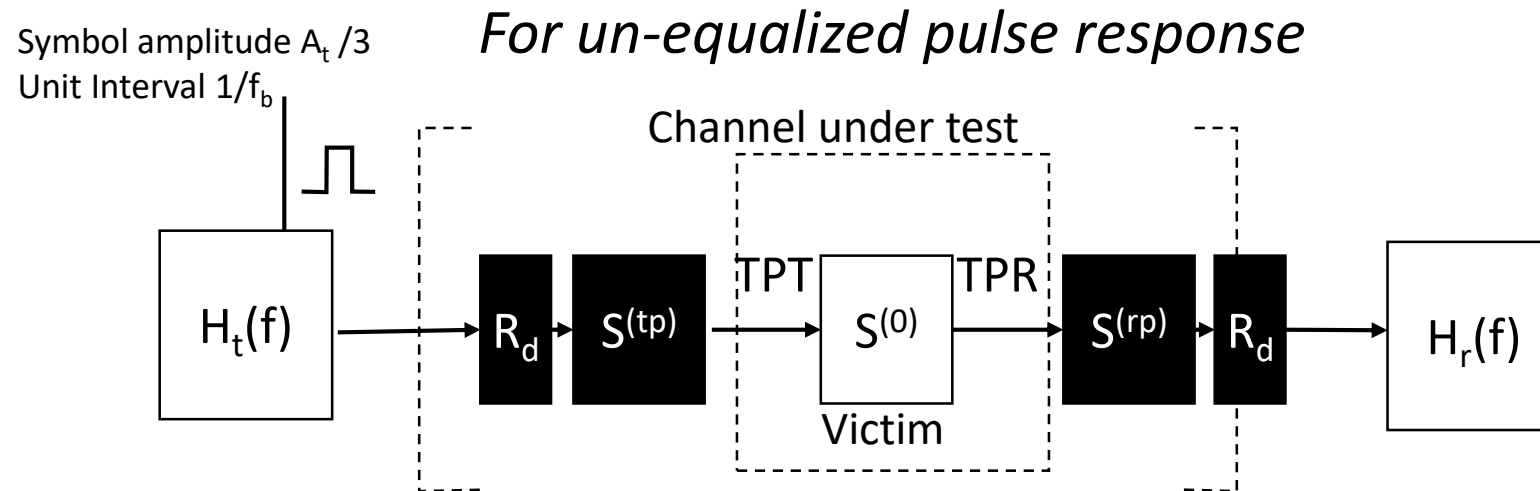
--CaBP_BGAVlas_Opt1_28dB_THRU

Window Help

The pulse response should not be negative going.

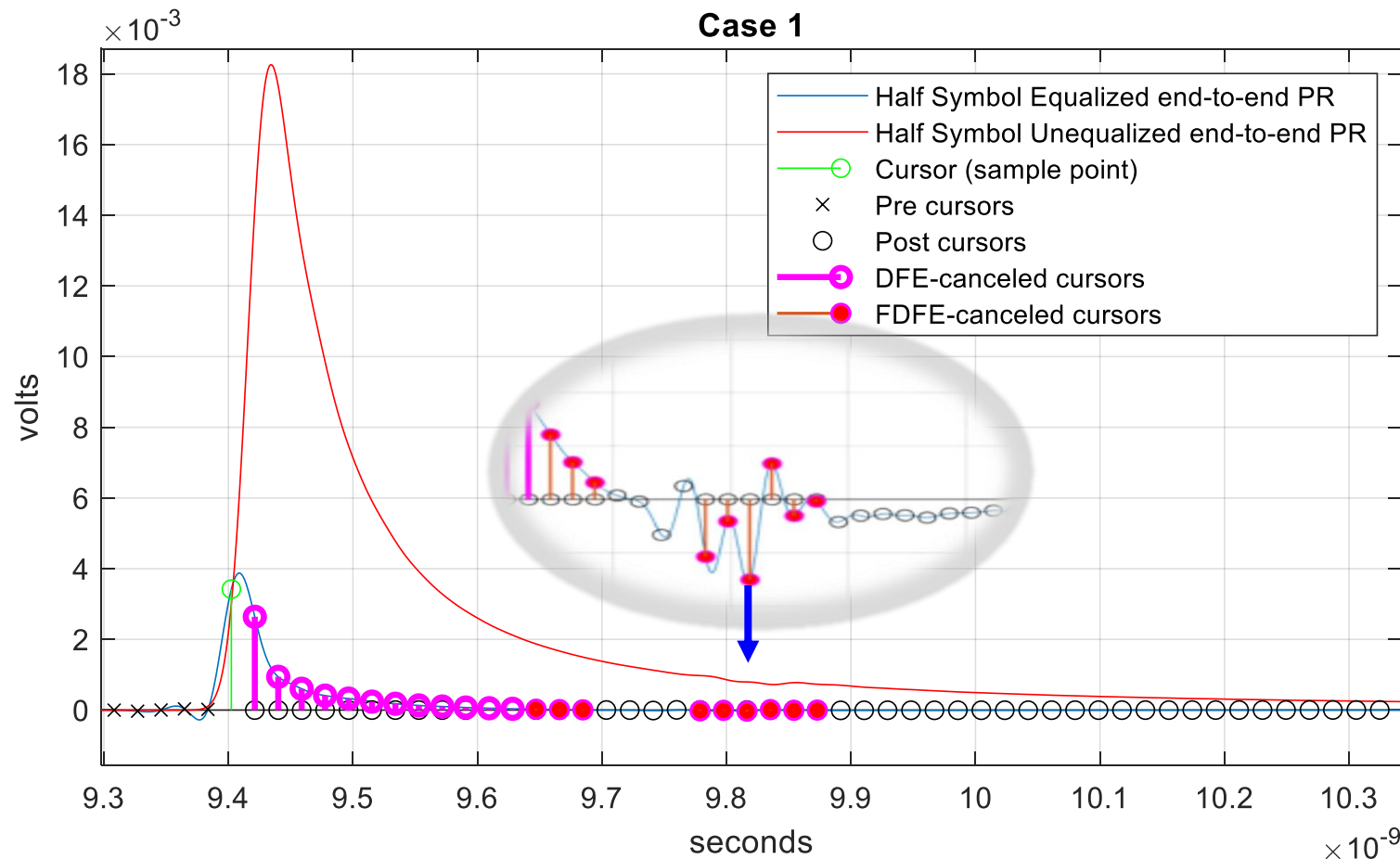


Plotted Pulse Responses



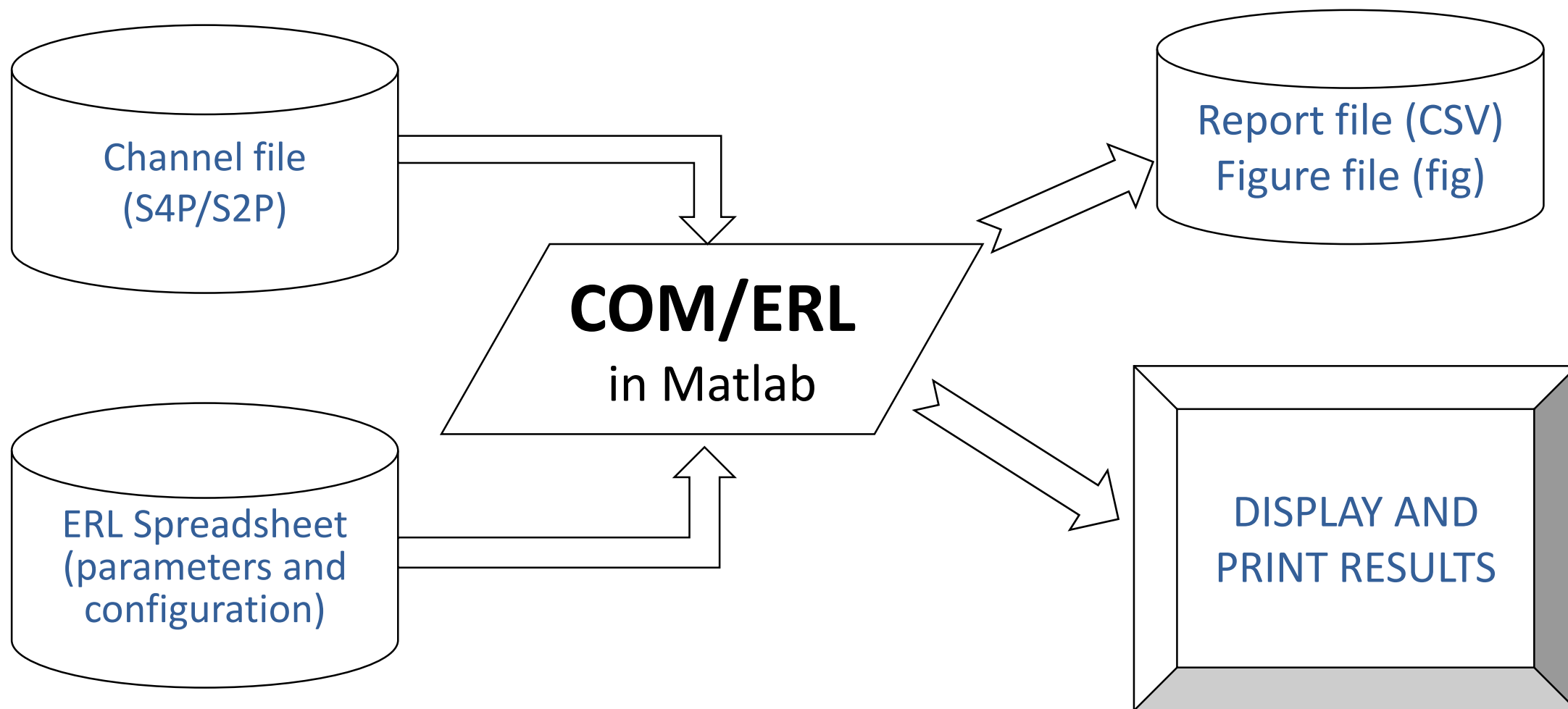
Closer look at the Pulse Response

```
my_var=...  
com_ieee8023_93a_310('config_com_ieee8023_93a=3ck_dlp4_KR_01_11_21.mat',...  
0,0,'CaBP_BGAVia_Opt2_28dB_THRU.s4p','OP.pkg_len_select','2');
```



- Pulse responses are half symbol or single sided symbol pulses
- The red curve is the unequalized pulse response
- The blue curve is the equalized pulse response
- The magenta dots are the non-floating DFE voltage cursors removed from signal
- The red dots are the floating DFE voltage cursors removed from signal
- The black dots are the ISI cursors

Basic ERL Flow



100 Gbps KR Spreadsheet with ERL Only set to 1

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]		[test cases to run]
z_p (TX)	[31; 1.8]	mm	[test cases]
z_p (NEXT)	[0 ; 0]	mm	[test cases]
z_p (FEXT)	[31; 1.8]	mm	[test cases]
z_p (RX)	[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	0.413	V	
A_fe	0.413	V	
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	0		[min:step:max]
c(-2)	0		[min:step:max]
c(-3)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	12	UI	
b_max(1)	1		
g_DC	0	dB	[min:step:max]
f_z	1000	GHz	
f_p1	1000	GHz	
f_p2	2000	GHz	
g_DC_HP	0		[min:step:max]
f_HP_PZ	0.00001	GHz	
N_v	200	UI	for Vf

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_TPV_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	ERL_TPV_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	0.0001	
T_r	0.0075	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
SAVE_TD	1	logical
Impulse response truncation threshold	0.000001	V^2/GHz
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	1	logical
TR_TDR	0.01	ns
N	3500	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0	UI
A_DD	0	UI
eta_0	1.00E-16	V^2/GHz
SNR_TX	1000	dB
R_LM	1	

Table 93A-3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
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)	110.3	mm
z_bp (NEXT)	110.3	mm
z_bp (FEXT)	110.3	mm
z_bp (RX)	110.3	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	0	logical
Floating Tap Control		
N_bg	0	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN & FOM_ILD parameters		
f_v	0.594	*Fb
f_f	0.594	*Fb
f_n	0.594	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	0.600	V

Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V

Find ERL for a Channel without Computing COM

```
My_results =  
com_ieee8023_93a_310('config_ERL_TPV_ieee8023_93a=3ck_d1p4_KR_01_11_21.xlsx',0,0, ...  
    'CaBP_BGAVIas_Opt1_28dB_THRU.s4p')
```

This is NOT an official IEEE document.

Revision: 3.10 This is a computation example for exploring COM and ERL

for projects like IEEE P802.3bj/b/bs/cd/ck with some exploratory extensions and is not normative or official
run time = 0.439199 min

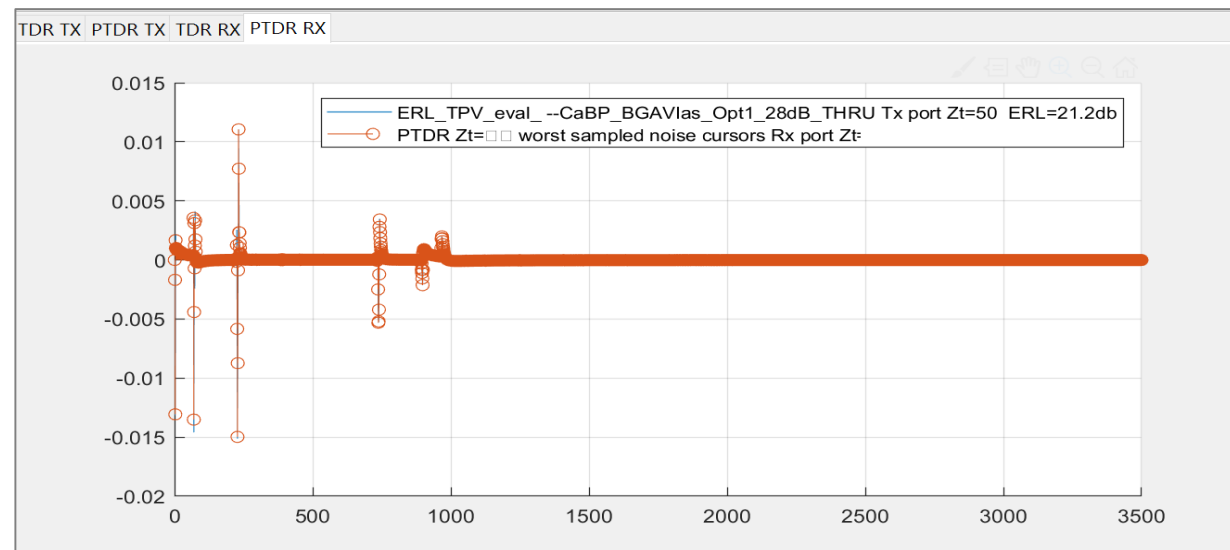
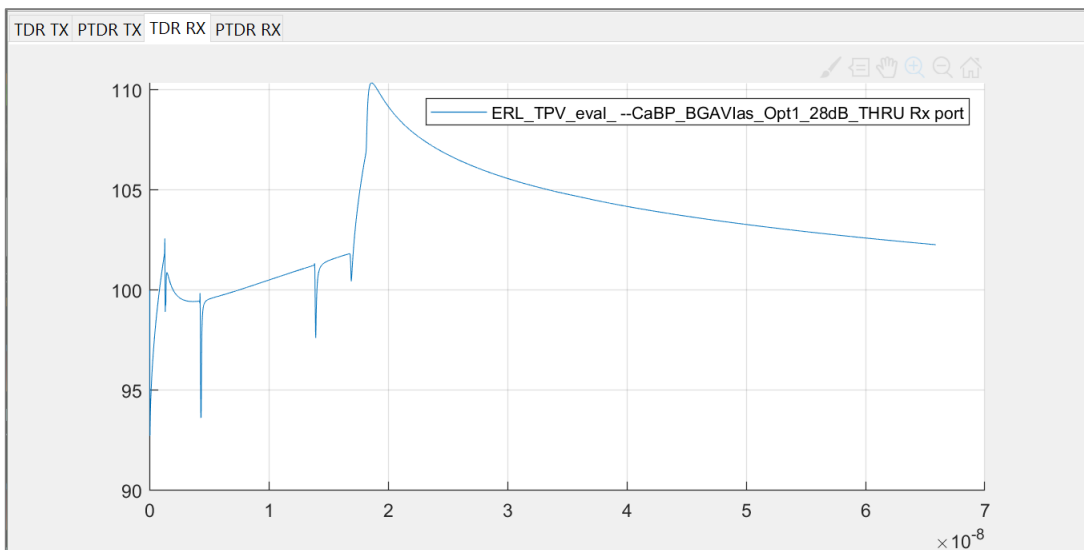
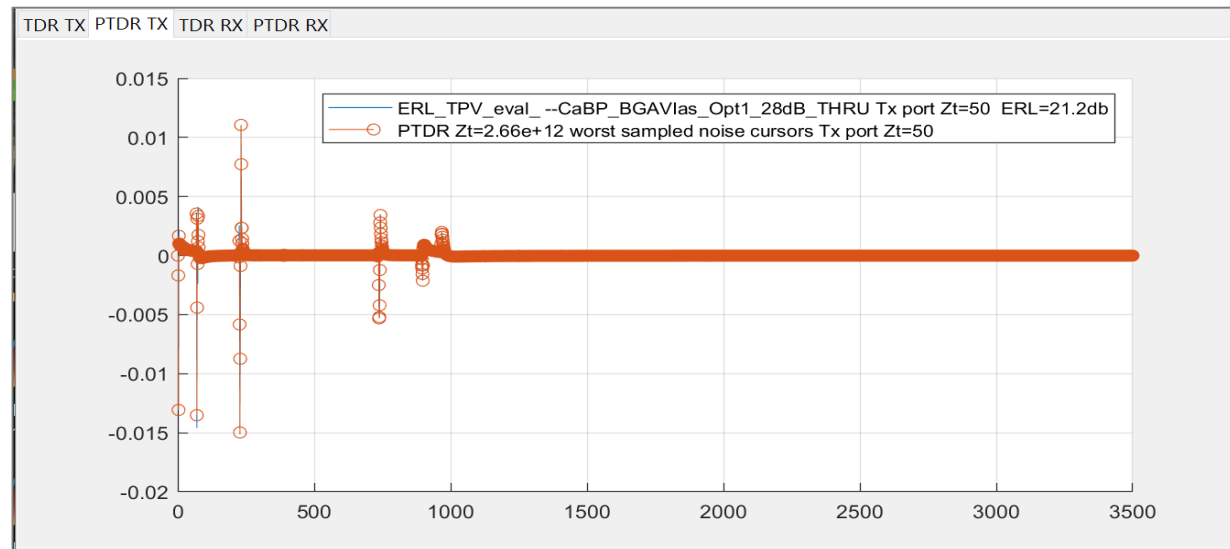
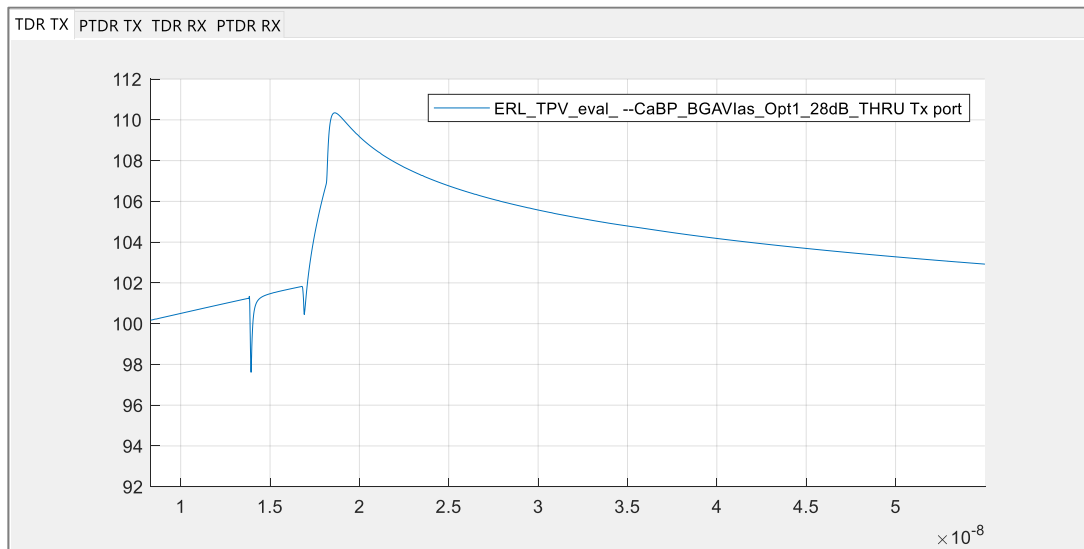
WC All cases: PASS ... ERL = 21.210 dB (21.210 dB, 21.210 dB)

redo string is: eval(['My_var_0 = ' getappdata(0,'cmd_str')])

```
My_results =  
    struct with fields:  
        code_revision: '3.10'  
        RL: [1x1 struct]  
        Z11est: 99.9936  
        Z22est: 99.9936  
        ERL11: 21.2096  
        ERL22: 21.2096  
        ERL: 21.2096  
        OP: [1x1 struct]  
        param: [1x1 struct]  
        chdata: [1x1 struct]  
        config_file: 'config_ERL_TPV_ieee8023_93a=3ck_d1p4_KR_01_11_21.xlsx'  
        Z_t: 50  
        file_names: '"ERL_TPV_eval_ --CaBP_BGAVIas_Opt1_28dB_THRU"'
```

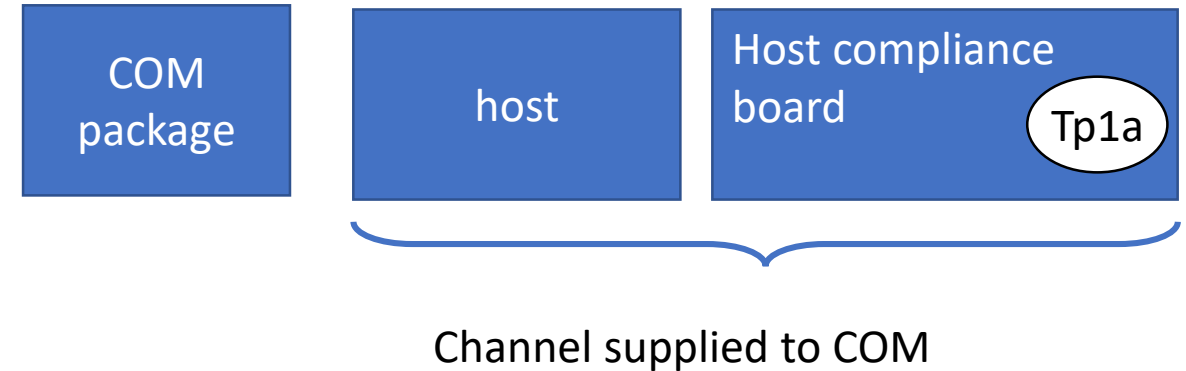
KR Channel from prior slide

Figure 4 Tabs with Tx/Rx TDR and PTDR



ERL Example for Chip to Module Host (C2M)

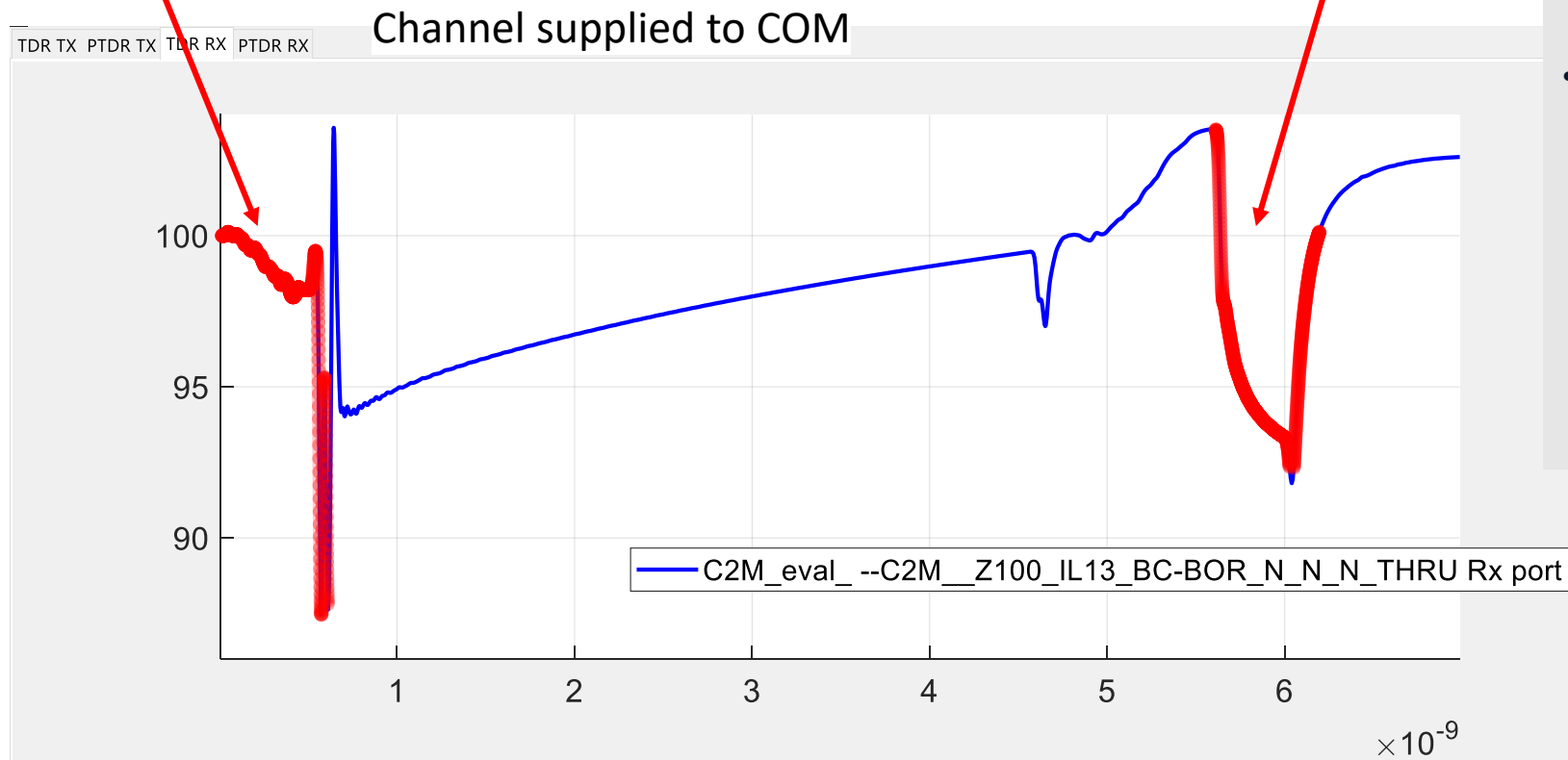
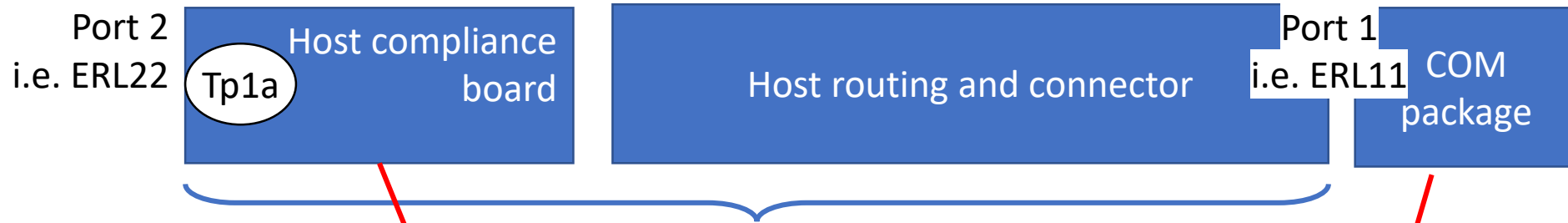
- Like OIF VSR
- ERL parameter from standard are different that for KR (backplane)
- ERL parameter may be found in IEEE802.3 draft 1.4 Annex 120 G.
- ERL for a host include the Tx package
 - **TDR_W_TXPKG** set to 1
- Per .3ck d1.5, the fixture delay is set to 0.2 ns for port 2 (Tp1a)



TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	1	logical
TR_TDR	0.01	ns
N	800	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0.2e-9]	[port1 port2]
TDR_W_TXPKG	1	
N_bx	0	UI
Tukey_Window	1	

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	[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]

TDR Illustrates ERL at Port 2 at the Specified Parameter

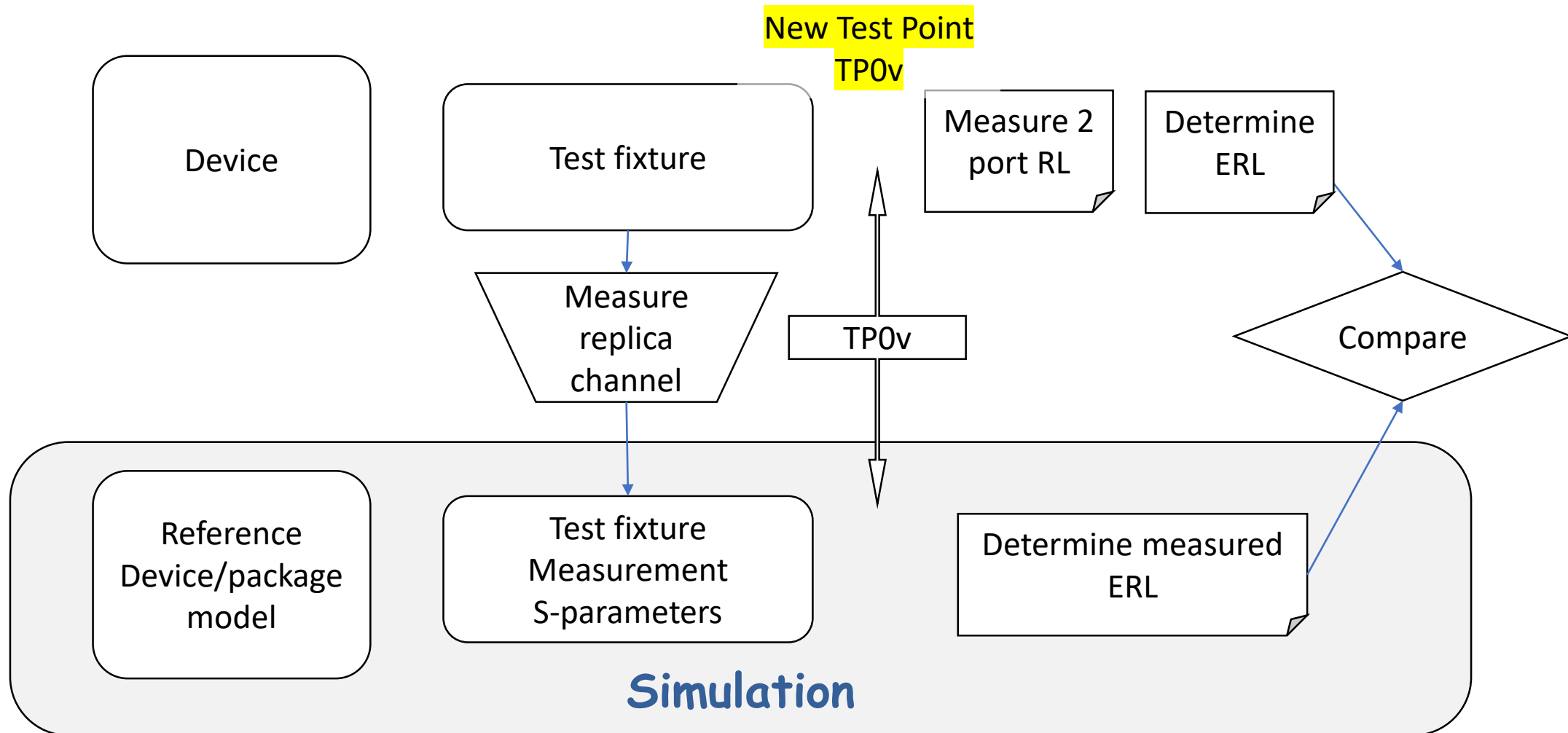


- ERL22 may be used as a compliance estimate
- ERL11 is reported at a location which is not at a compliance test point
 - Provided for information only

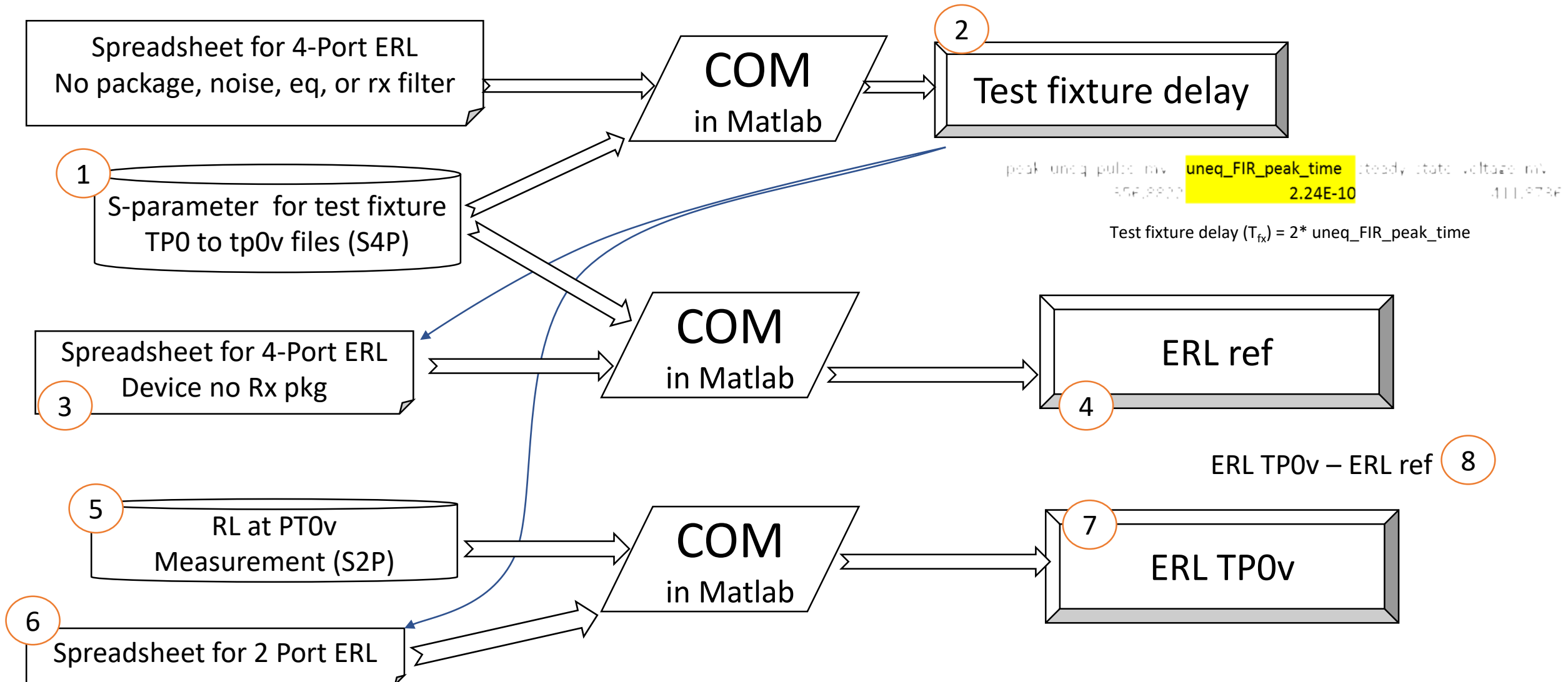
Preview of Advanced Topics

- ERL Test Point V – Brief description
- For future presentations
 - Determining V final
 - Determining V peak
 - Passing parameter to the COM script

ERL using Test Point V (IEEE802.3ck)



ERL Process at TP0v: Brief Introduction



Configuration Sheet to find Fixture Delay

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	[0 0]	nF	[TX RX]
L_s	[0 0]	nH	[TX RX]
C_b	[0 0]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[0 ; 0]	mm	[test cases]
z_p (NEXT)	[0 ; 0]	mm	[test cases]
z_p (FEXT)	[0 ; 0]	mm	[test cases]
z_p (RX)	[0 ; 0]	mm	[test cases]
C_p	[0 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.413	V	
A_fe	0.413	V	
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	0		[min:step:max]
c(-2)	0		[min:step:max]
c(-3)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	0	UI	
b_max(1)	1		
g_DC	0	dB	[min:step:max]
f_z	1000	GHz	
f_p1	1000	GHz	
f_p2	2000	GHz	
g_DC_HP	0		[min:step:max]
f_HP_PZ	0.00001	GHz	
N_v	200	UI	for Vf

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_TP V_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	ERL_TPV_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	0.0001	
T_r	0.001	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
SAVE_TD	1	logical
Impulse response truncation threshold	0.000001	V^2/GHz
TDR and ERL options		
TDR	0	logical
ERL	0	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3500	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0	UI
A_DD	0	UI
eta_0	1.00E-16	V^2/GHz
SNR_TX	1000	dB
R_LM	1	

Table 93A-3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
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)	110.3	mm
z_bp (NEXT)	110.3	mm
z_bp (FEXT)	110.3	mm
z_bp (RX)	110.3	mm
C_0	[0.29e-4]	nF
1	[0.19e-4]	nF
Include PCB		
1	0	logical
Floating Tap Control		
N_bg	0	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN & FOM_ILD parameters		
f_v	4.452	*Fb
f_f	4.452	*Fb
f_n	4.452	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	0.600	V

Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V

Configuration Sheet to Measure Device under Test ERL (with s2p RL) File

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]		[test cases to run]
z_p (TX)	[31; 1.8]	mm	[test cases]
z_p (NEXT)	[0 ; 0]	mm	[test cases]
z_p (FEXT)	[31; 1.8]	mm	[test cases]
z_p (RX)	[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	0.413	V	
A_fe	0.413	V	
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	0		[min:step:max]
c(-2)	0		[min:step:max]
c(-3)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	12	UI	
b_max(1)	1		
g_DC	0	dB	[min:step:max]
f_z	1000	GHz	
f_p1	1000	GHz	
f_p2	2000	GHz	
g_DC_HP	0		[min:step:max]
f_HP_PZ	0.00001	GHz	
N_v	200	UI	for Vf

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_TP V_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	ERL_TPV_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	0.0001	
T_r	0.0075	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
SAVE_TD	1	logical
Impulse response truncation threshold	0.000001	V^2/GHz
TDR and ERL options		
TDR	1	logical
ERL	2	logical
ERL_ONLY	1	logical
TR_TDR	0.01	ns
N	3500	
beta_x	0	
rho_x	0.618	
fixture delay time	[4.0824e-10]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0	UI
A_DD	0	UI
eta_0	1.00E-16	V^2/GHz
SNR_TX	1000	dB
R_LM	1	

Table 93A-3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
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)	110.3	mm
z_bp (NEXT)	110.3	mm
z_bp (FEXT)	110.3	mm
z_bp (RX)	110.3	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	0	logical
Floating Tap Control		
N_bg	0	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN & FOM_ILD parameters		
f_v	0.594	*Fb
f_f	0.594	*Fb
f_n	0.594	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	0.600	V

Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V

Configuration Sheet to Determine Reference ERL

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]		[test cases to run]
z_p (TX)	[31; 1.8]	mm	[test cases]
z_p (NEXT)	[0 ; 0]	mm	[test cases]
z_p (FEXT)	[31; 1.8]	mm	[test cases]
z_p (RX)	[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	0.413	V	
A_fe	0.413	V	
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	0		[min:step:max]
c(-2)	0		[min:step:max]
c(-3)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	12	UI	
b_max(1)	1		
g_DC	0	dB	[min:step:max]
f_z	1000	GHz	
f_p1	1000	GHz	
f_p2	2000	GHz	
g_DC_HP	0		[min:step:max]
f_HP_PZ	0.00001	GHz	
N_v	200	UI	for Vf

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_TP V_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	ERL_TP_V_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	0.0001	
T_r	0.0075	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
SAVE_TD	0	logical
Impulse response truncation threshold	0.000001	V^2/GHz
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	1	logical
TR_TDR	0.01	ns
N	400	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 4.0824e-10]	[port1 port2]
TDR_W_TXPKG	1	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0	UI
A_DD	0	UI
eta_0	1.00E-16	V^2/GHz
SNR_TX	1000	dB
R_LM	1	

Table 93A-3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
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)	110.3	mm
z_bp (NEXT)	110.3	mm
z_bp (FEXT)	110.3	mm
z_bp (RX)	110.3	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	0	logical
Floating Tap Control		
N_bg	0	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN & FOM_ILD parameters		
f_v	0.594	*Fb
f_f	0.594	*Fb
f_n	0.594	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	0.600	V

Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V



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