COM Simulation for 100G KR/CR Channels

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Introduction

- A large number of COM simulations were conducted for all 115 KR/CR channels submitted to P802.3ck TF (including 100GEL SG) under 15 simulation conditions

- All results were consolidated into an Excel file with additional information (e.g. channel loss, equalizer settings) and interactive graphs for easy visualization
  - We are providing the excel file to Task Force for further examination and your own analysis

- This presentation explains how to use the Excel file

Simulation Conditions

Model Name		DFE (DFE-based)	PDFE (DFE + 3 pre-taps)	FFE (FFE-based)
# of taps	DFE	20	20	1
	FFE	0	4 (3-pre + 0-post)	24 (3-pre + 20-post)
	TX FIR	5 (3-pre + 1-post)		
Step	RX DFE, FFE	0%		
	TX FIR pre	1.5% / 2.0% / 2.5%	1.5% / 2.5%	1.5% / 2.0% / 2.5%
	TX FIR post	5%		
DFE b1max		0.7 / 0.85 / 1.0	0.7 / 0.85 / 1.0	0.7 / 0.85

- Label of Simulation Condition: Prefix + Model Name + Suffix
  - Prefix: step of TX FIR pre taps
    - None: 1.5%, C (coarse): 2.5%, M (Medium): 2.0%
  - Suffix: DFE b1max value
  - Example
    - CDFE0.85: DFE-based with DFE b1max=0.85 and 2.5% step of TX FIR pre taps
    - PDFE0.7: DFE + pre-taps with DFE b1max=0.7 and 1.5% step of TX FIR pre taps

Matrix of Conducted Simulation Conditions

- Simulations were done for the following 15 combinations of TX FIR pre step and DFE b1max:

TX FIR pre step	Model Name	Labels of Conducted Simulation Conditions		
		DFE b1max		
		0.7	0.85	1.0
1.5%	DFE (DFE-based)	DFE0.7	DFE0.85	DFE1.0
	PDFE (DFE + 3 pre-taps)	PDFE0.7	PDFE0.85	PDFE1.0
	FFE (FFE-based)	FFE0.7	FFE0.85	
2.5%	DFE (DFE-based)	CDFE0.7	CDFE0.85	
	PDFE (DFE + 3 pre-taps)	CPDFE0.7	CPDFE0.85	
	FFE (FFE-based)	CFFE0.7		
2.0%	DFE (DFE-based)		MDFE0.85	
	PDFE (DFE + 3 pre-taps)			
	FFE (FFE-based)	MFFE0.7		

Other Simulation Conditions

- Equalizer ranges
  - RX FFE taps
    - main_min = 0.7, pre1_max = 0.3, post1_max = 0.3, tapn_max = 0.125
  - RX CTLE
    - gDC ∈ [-20,0], gDC2 ∈ [-6,0]
  - TX FIR tap
    - c(-3) ∈ [-0.105,0], c(-2) ∈ [0,+0.105], c(-1) ∈ [-0.3,0], c(1) ∈ [-0.15,0]
      - This is the case of 1.5% pre tap step to align 0 on the grid
- Package Model (Tx and Rx)
  - 30mm @ 87.5Ω + 1.8mm @ 92.5Ω
  - C_d = 110fF, C_p = 70fF, R_d = 50Ω
- Noise, jitter
  - η_0=8.20E-9V^2/GHz, SNR_{TX}=32.5dB, σ_{RJ}=0.01UI, A_{DD}=0.02UI, R_{LM}=0.95
- COM Tool version
  - v2.53 + local modification to fix bugs

Channels Used for Simulation

- Simulation was done for the following publicly available 115 KR/CR channels

CH #	Group	Description	Reference Document
1-2	RM1	Two Very Good 28dB Loss Ideal Transmission Lines	mellitz_3ck_adhoc_02_072518.pdf
3-8	RM2	24/28/32dB Cabled Backplane Channels including Via	mellitz_3ck_adhoc_02_081518.pdf
9-10	RM3	Synthesized CR Channels (2.0m and 2.5m 28AWG Cable)	mellitz_100GEL_adhoc_01_021218.pdf
11-13	RM4	Best Case 3”, 13”, 18” Tachyon Backplane	mellitz_100GEL_adhoc_01_010318.pdf
14-15	NT1	Orthogonal or Cabled Backplane Channels	tracy_100GEL_03_0118.pdf
16	AZ1	Orthogonal Backplane Channel	zambell_100GEL_01a_0318.pdf
17-19	HH1	Initial Host 30dB Backplane Channel Models	heck_100GEL_01_0118.pdf
20-35	HH2	16/20/24/28dB Cabled Backplane Channels	heck_3ck_01_1118.pdf
36-54	UK1	Measured Traditional Backplane Channels	kareti_3ck_01a_1118.pdf
55-73	UK2	Measured Cabled Backplane Channels	
74-88	UK3	Measured Orthogonal Backplane Channels	
89-115	AZ2	Measured Orthogonal Backplane with Varied Impedances	zambell_3ck_01_1118.pdf

All channel data are taken from IEEE 100GEL Study Group and P802.3ck Task Force – Tools and Channels pages.
i.e. http://www.ieee802.org/3/100GEL/public/tools/index.html and http://www.ieee802.org/3/ck/public/tools/index.html

Sheet ‘data’ has all the detail data values (1/2)

Expand / collapse non-representative channels

Expand / collapse detail channel properties such as Insertion Loss (only Note is shown when collapsed)

Expand / collapse detail sim results (only COM is shown when collapsed)

Cross reference channel # to previous presentations

Simulation condition

Label of simulation condition

Channel # with a hyperlink to reference document

Notes for representative channels (add/clear the cell to change selection of representative channels)

		Cross ref channel #																						
	CH#	hidaka_3ck_adhoc_01_102418	lu_3ck_01_1118	sakai_3ck_01a_1118	li_3ck_02a_1118	file name (THRU)	Total IL @ 26.5625 GHz	IL @ 26.5625 GHz	Fitted IL @ 26.5625 GHz	FOM_ILD (dB)	ERL (dB)	ICN (mV)	Note	COM	TX FIR	DFE	CTLE DC gain		Detail	COM	COM			
															[1]	[20]	gDC	gDC2	FOM					
														with RX DFE (pre/post=0/20) (TX=1.5%,RX=0%) (b1max=0.7)	with RX DFE (pre/post=0/20) (TX=1.5%,RX=0%) (b1max=0.85)					with RX DFE (pre/post=0/20) (TX=1.5%,RX=0%) (b1max=1.0)					
														DFE0.7	DFE0.85					DFE1.0				
5	1	1		4		Z0d_100_14p25in_2dBpi_meg6_rtf	40.52	27.98	28.01	0.03	44.15	0.0		3.5305	0	0.013858	-19	-2	15.3986	4.1943	4.2225			
6	2	2		11		Z0d_100_206in_0p13dBpi_twinax26_smooth	40.52	27.98	27.98	0.00	100.0			3.2609	0	0.011243	-18	-4	14.8651	3.6752	3.6487			
7	3	3	26	5		CaBP_BGAVia_Opt1_24dB_THRU	35.89	23.33	23.79	0.23	0.76			4.642	0	0.010409	-15	-4	15.5101	4.6272	4.6272			
8	4		27	7		CaBP_BGAVia_Opt1_28dB_THRU	39.79	27.15	27.59	0.56			High loss, smooth	3.3371	0	0.012565	-18	-4	14.3765	3.4397	3.4397			
11	7					CaBP_BGAVia_Opt2_28dB_THRU							High loss, smooth	3.596	0	0.009364	-16	-4	14.5225	3.7819	3.7284			
18	14					G1112_Thru_Ortho							Low loss, high ILD	4.7464	0	0.005682	-12	-3	15.8349	4.7464	4.7464			
19	15					B56_Thru_CblBP							Low loss, high ILD	3.7551	0	0.02033	-13	-3	14.9504	3.8764	3.8764			
25	21					BKP_16dB_0p575m_more_is							oward's choice 1 (reflection)	4.2084	0	0.046412	-9	-2	15.049	4.2084	4.2084			
27	23					BKP_16dB_0p995m_more_is							Very low loss, high XT	4.9898	0	0.010822	-8	-2	15.6427	4.9898	4.9898			

- From this sheet, you can extract various data values for your own analysis

Sheet ‘data’ has all the detail data values (2/2)

Expand / collapse TXFIR tap coefficients

Expand / collapse DFE tap coefficients

Expand / collapse σ_G breakdown

Expand / collapse σ(p_n) breakdown

Expand / collapse Ani/As breakdown

Expand / collapse detail sim results (only COM is shown when collapsed)

Ani scaled by As

Standard deviation of crosstalk scaled by As

Standard deviation of ISI scaled by As

Standard deviation of noise (σ(p_n)) scaled by As

Standard deviation of dual-dirac noise scaled by As

Standard deviation of Gaussian noise (σ_G) scaled by As

As in mV

Ani in mV

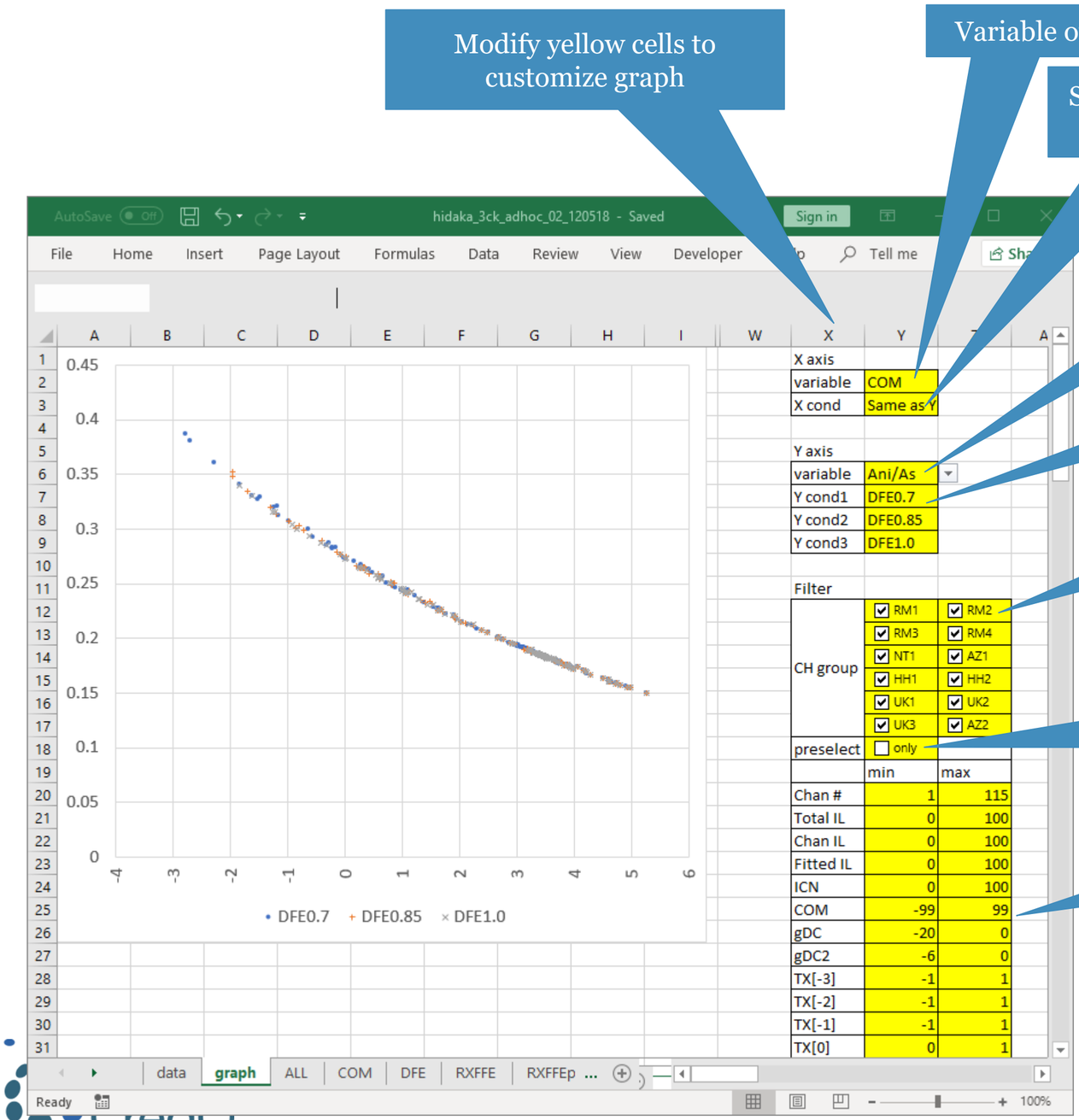
	A	BB	BC	BD	BE	BF	BG	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	ED
2		DFE0.7	DFE0.85																					DFE1.0
3			TX FIR					DFE	CTLE DC gain		Detail													
4	CH#	COM	[-3]	[-2]	[-1]	[0]	[1]	[20]	gDC	gDC2	As (mV)	Ani (mV)	σ_RJ σ_X sqrt(Σ(h_J^2)) / As	σ(η0noise) / As	σ_TX / As	σ_G / As	σ(p_DD) / As	σ(p_n) / As	σ(ISI) / As	σ(XT) / As	Ani / As	FOM		
5	1	3.5305	-0.015	0.06	-0.225	0.7	0	0.013858	-19	-3	2.9772	0.5047	0.030322	0.11359	0.074886	0.139393	0.060402	0.15173	0.075601	0	0.169522	15	4.1943	4.2335
6	2	3.2609	0	0.03	-0.18				-16	-3	2.6552	0.47799	0.029864	0.127633	0.074887	0.15096	0.063585	0.16208	0.078326	0	0.18002	14.8651	3.6752	
7	3	4.642	0	0.03	-0.18				-16	-3	3.7301	0.59392	0.03131	0.090469	0.074885	0.121544	0.062	0.136592	0.078124	0.033265	0.1608	15.5101	4.6272	
8	4	3.3371	0	0.03	-0.195	0.775	0	0.012565	-18	-4	2.6051	0.49128	0.030971	0.125182	0.074886	0.149122	0.061805	0.161227	0.083	0.032848	0.184345	14.5	3.4397	3
11	7	3.596	-0.015	0.06	-0.225	0.7	0	0.009364	-16	-4	2.6831	0.47688	0.03208	0.125184	0.074887	0.149361	0.064153	0.153	0.061328	247	0.177735	14.5225	3.7284	
18	14	4.7464	-0.03	0.075	-0.27	0.625	0	0.005682	-12	-3	3.8749	0.6139	0.029825	0.090067	0.074885	0.12087	0.059769	0.13	0.083001	0.0	0.158946	15.8349	4.7464	

data | graph | ALL | COM | DFE | RXFFE | RXFFEpre | TXFIR | FIR | index

Ready

$$\sigma_G^2 = \sigma_{TX}^2 + \sigma_{RJ}^2\sigma_X^2\sum_n h_J^2(n) + \eta_0\int_0^\infty \left|H_r(f)H_{ctf}(f)\right|^2 df \qquad p_n(y) = p_G(y) * p_{DD}(y)$$

Sheet ‘graph’ has General Interactive Graphs



Variables independent from simulation condition:
Chan #, Total IL, Chan IL, Fitted IL,
FOM_ILD, ERL, ICN

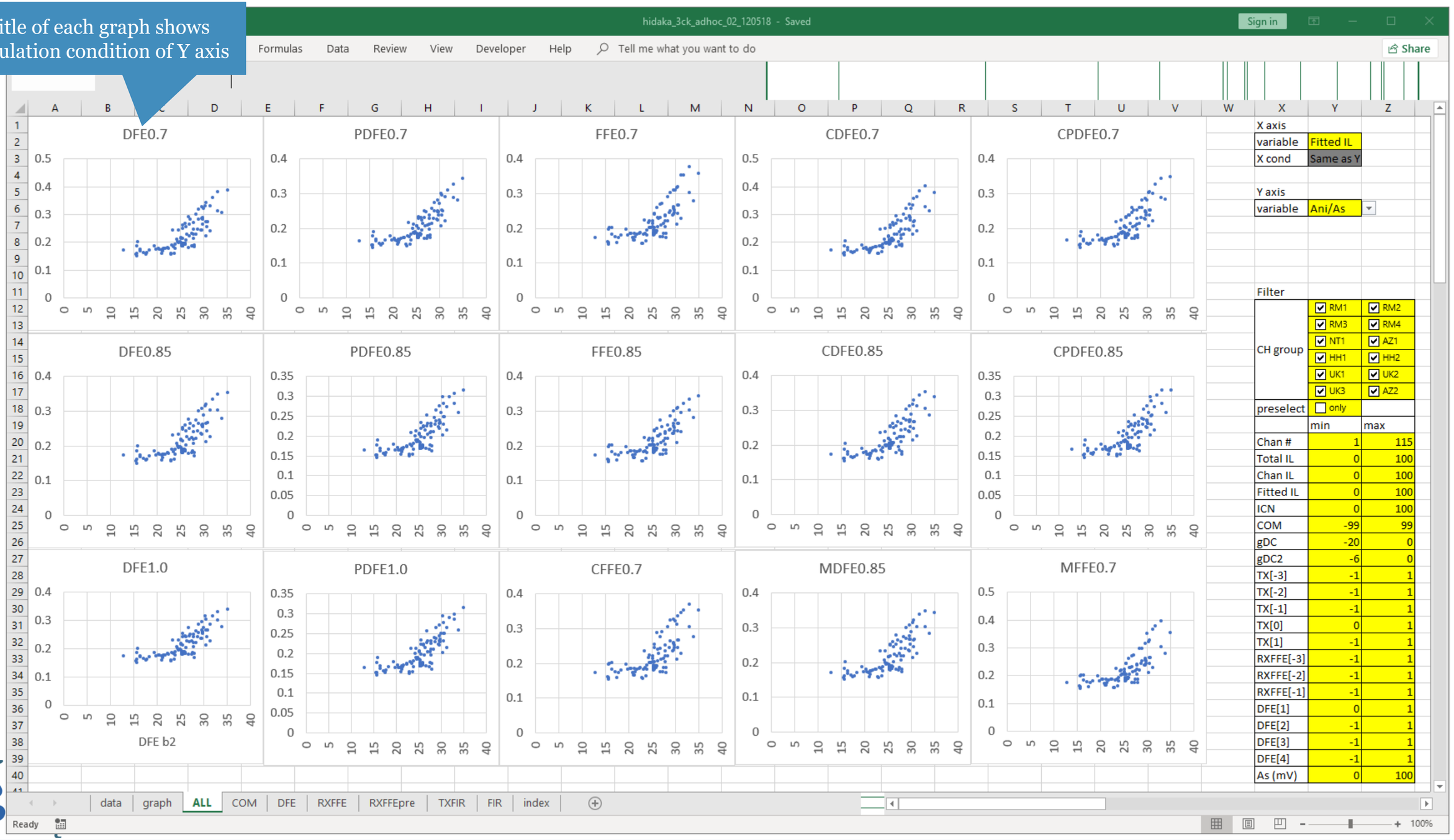
Variables depending on simulation condition:
COM, FOM, gDC, gDC2,
TX[-3:1], RXFFE[-3:20], DFE[1:20],
As (mV), Ani (mV), Ani/As, σ(XT)/As, σ(ISI)/As,
σ(p_n)/As, σ(p_DD)/As, σ_G/As,
σ_RJ σ_X sqrt(Σ(h_J^2)) / As,
σ(η0noise) / As, σ_TX/As

Simulation conditions:
Same as Y (only for X axis),
DFE0.7, DFE0.85, DFE1.0,
PDFE0.7, PDFE0.85, PDFE1.0,
FFE0.7, FFE0.85,
CDFE0.7, CDFE0.85,
CPDFE0.7, CPDFE0.85,
CFFE0.7, MDFE0.85, MFFE0.7

Simulation condition is shaded if variable is independent from simulation condition.

Sheet ‘ALL’ has 15 graphs for all sim conditions

Title of each graph shows simulation condition of Y axis



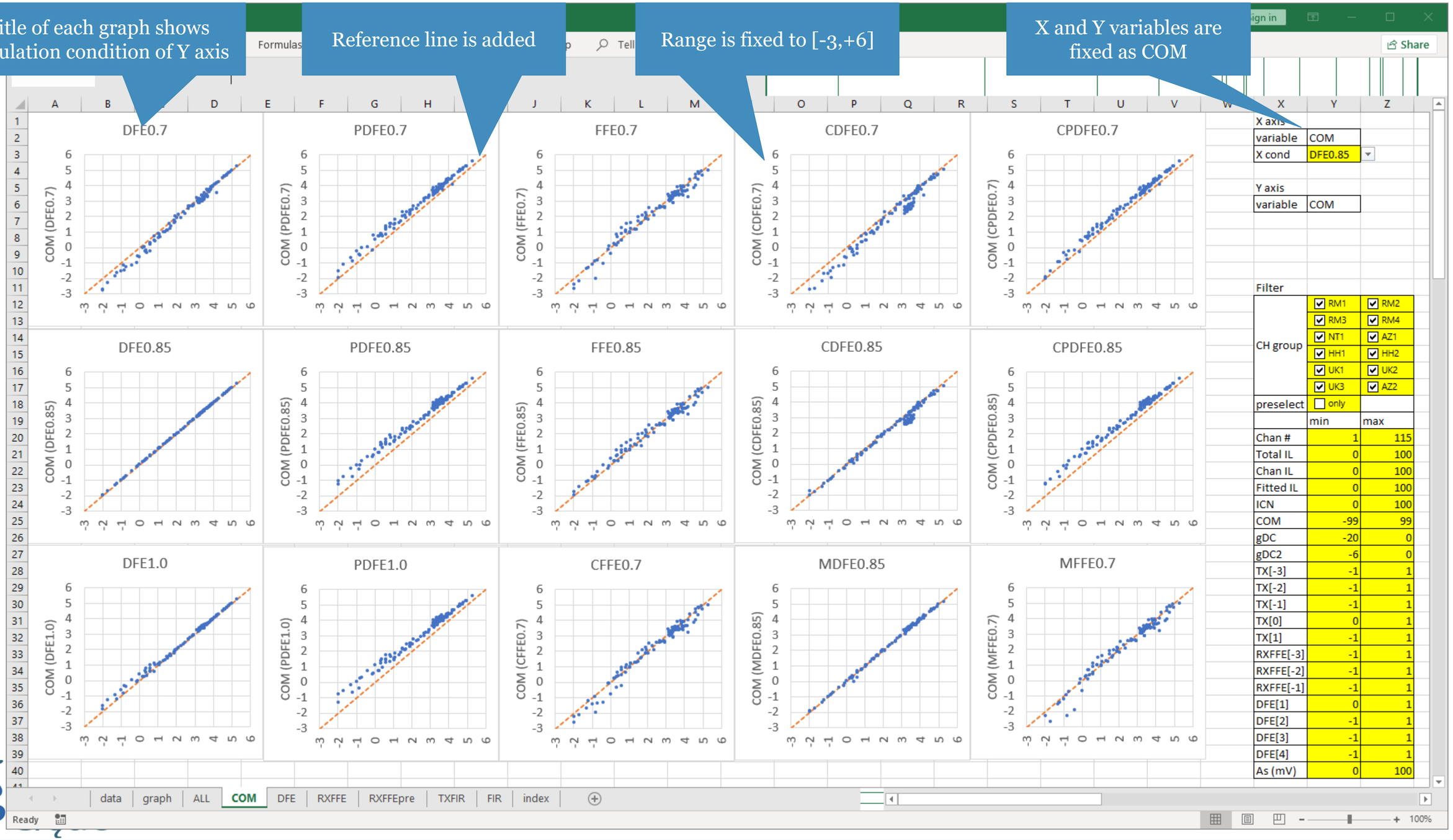
Sheet ‘COM’ has COM vs COM graphs

Title of each graph shows simulation condition of Y axis

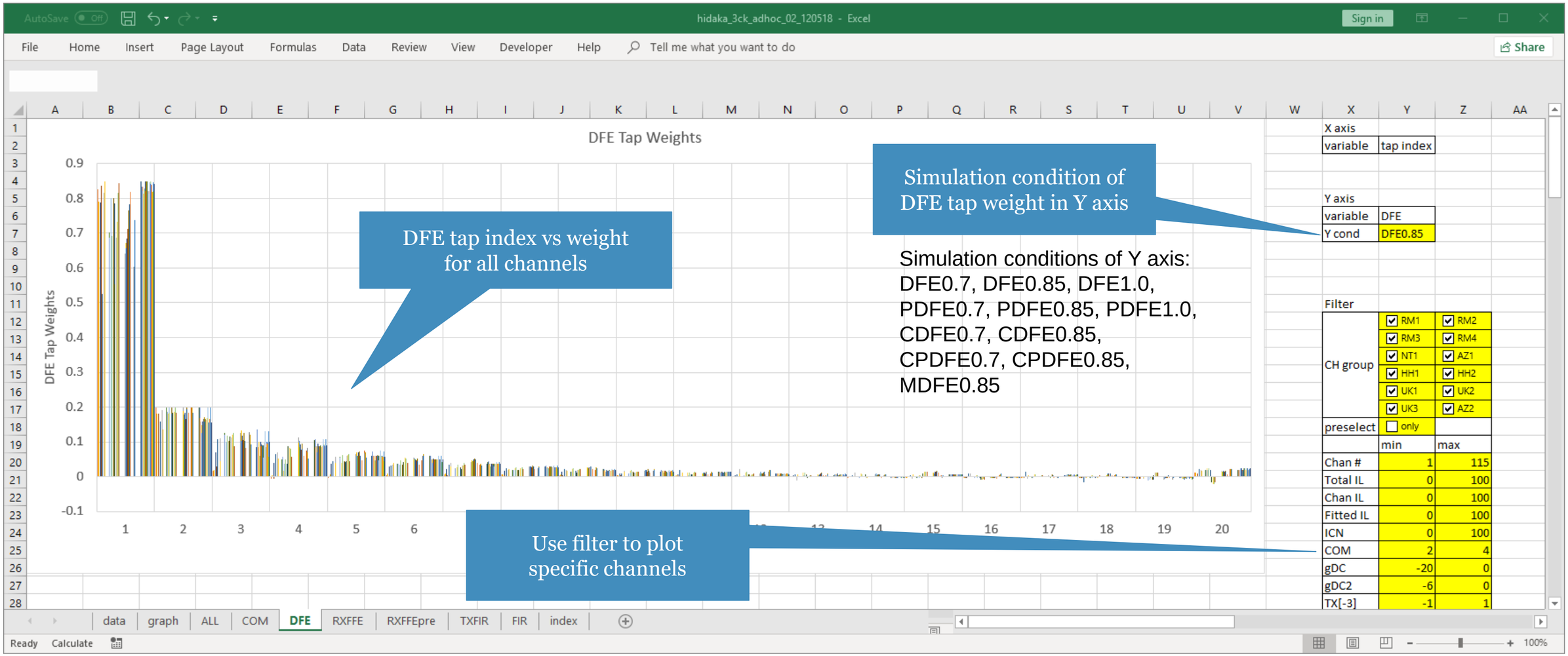
Reference line is added

Range is fixed to [-3,+6]

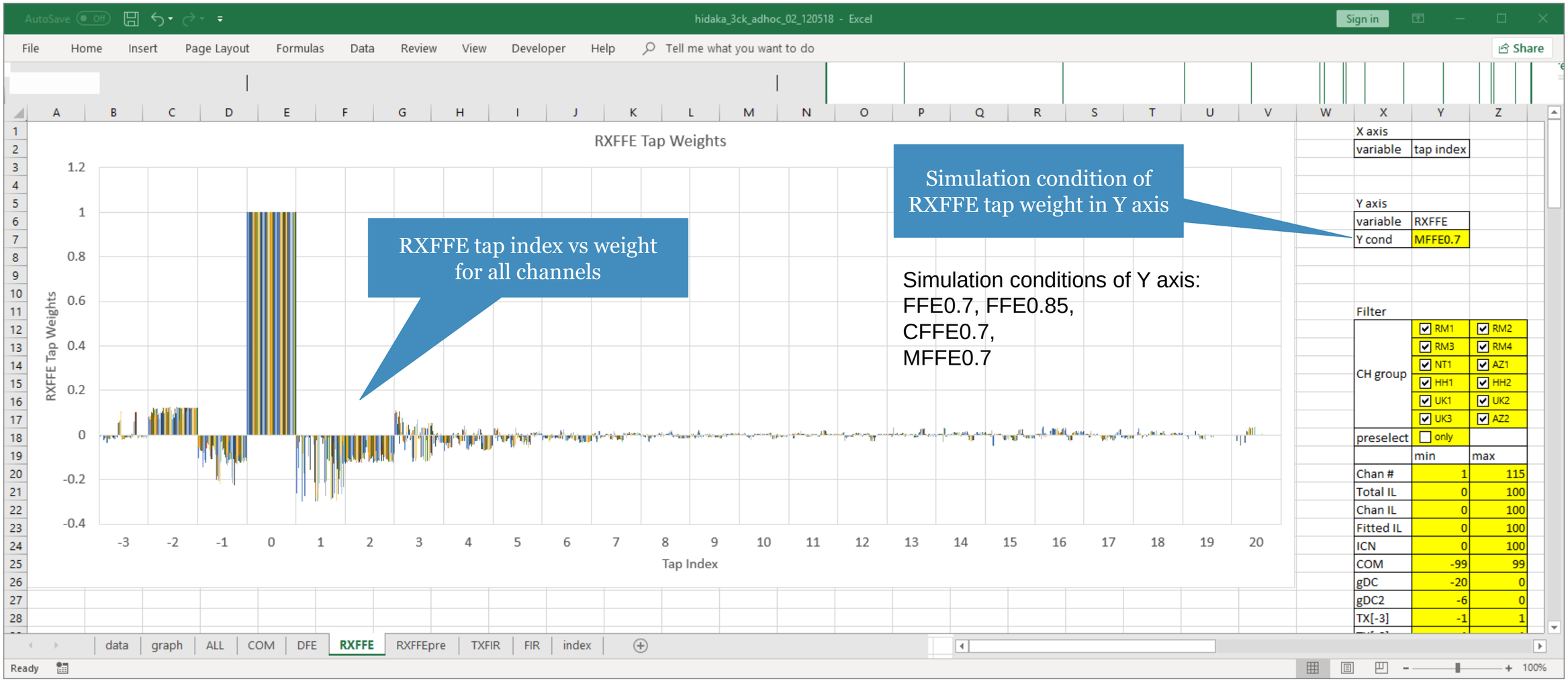
X and Y variables are fixed as COM



Sheet ‘DFE’ has DFE Tap Weight Graph

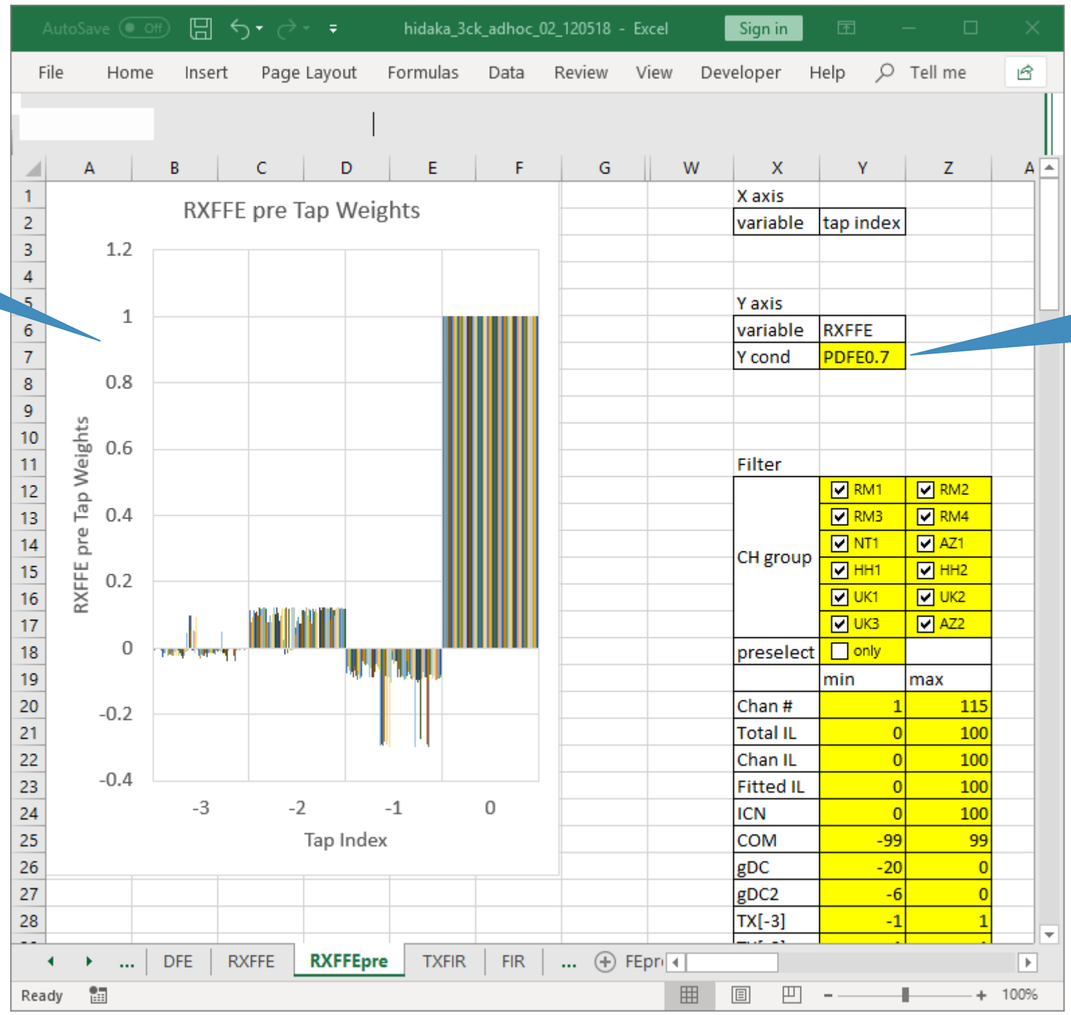


Sheet ‘RXFFE’ has RXFFE Tap Weight Graph



Sheet ‘RXFFEpre’ has RXFFE pre Tap Weight Graph

RXFFE pre-tap index vs weight for all channels

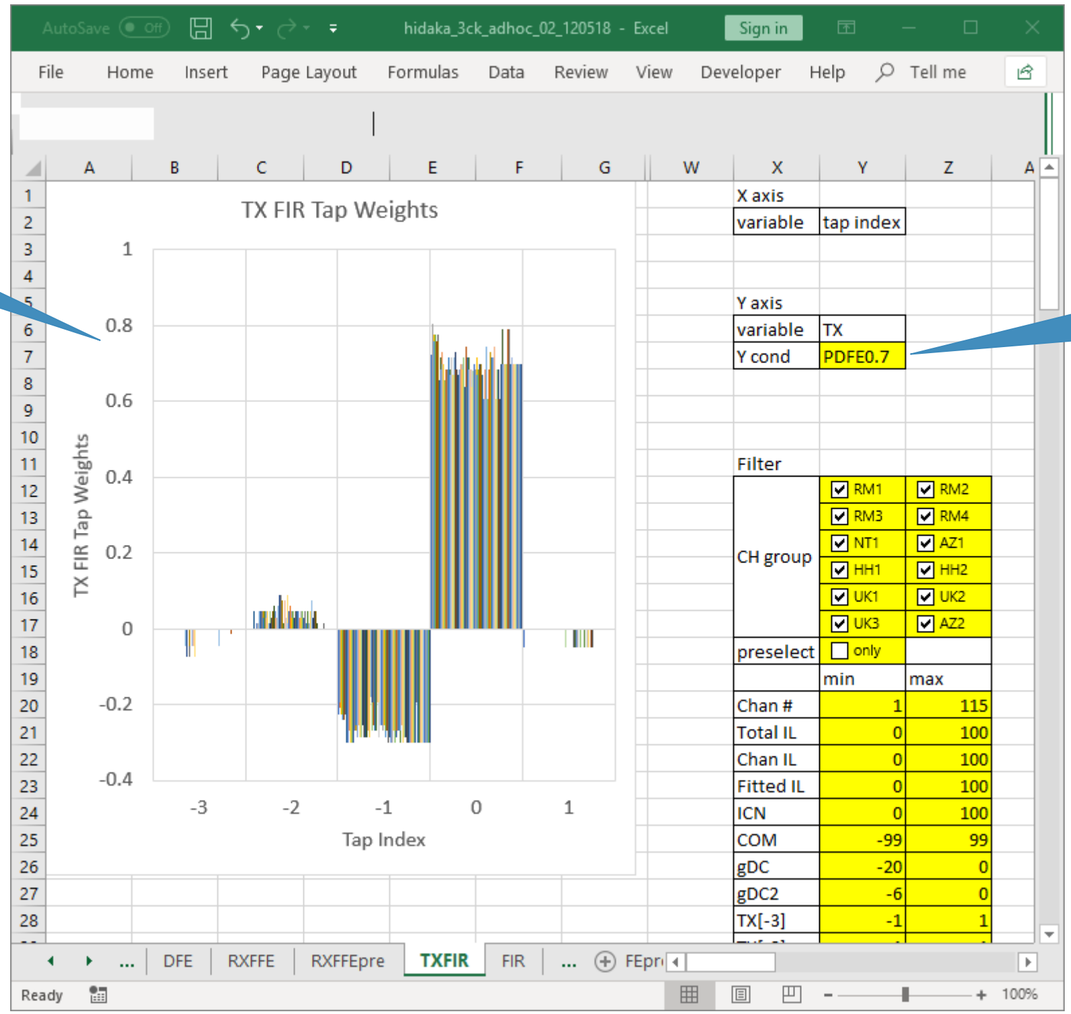


Simulation condition of RXFFE pre-tap weight in Y axis

Simulation conditions of Y axis:
PDFE0.7, PDFE0.85, PDFE1.0,
FFE0.7, FFE0.85,
CPDFE0.7, CPDFE0.85,
MFFE0.7

Sheet ‘TXFIR’ has TXFIR Tap Weight Graph

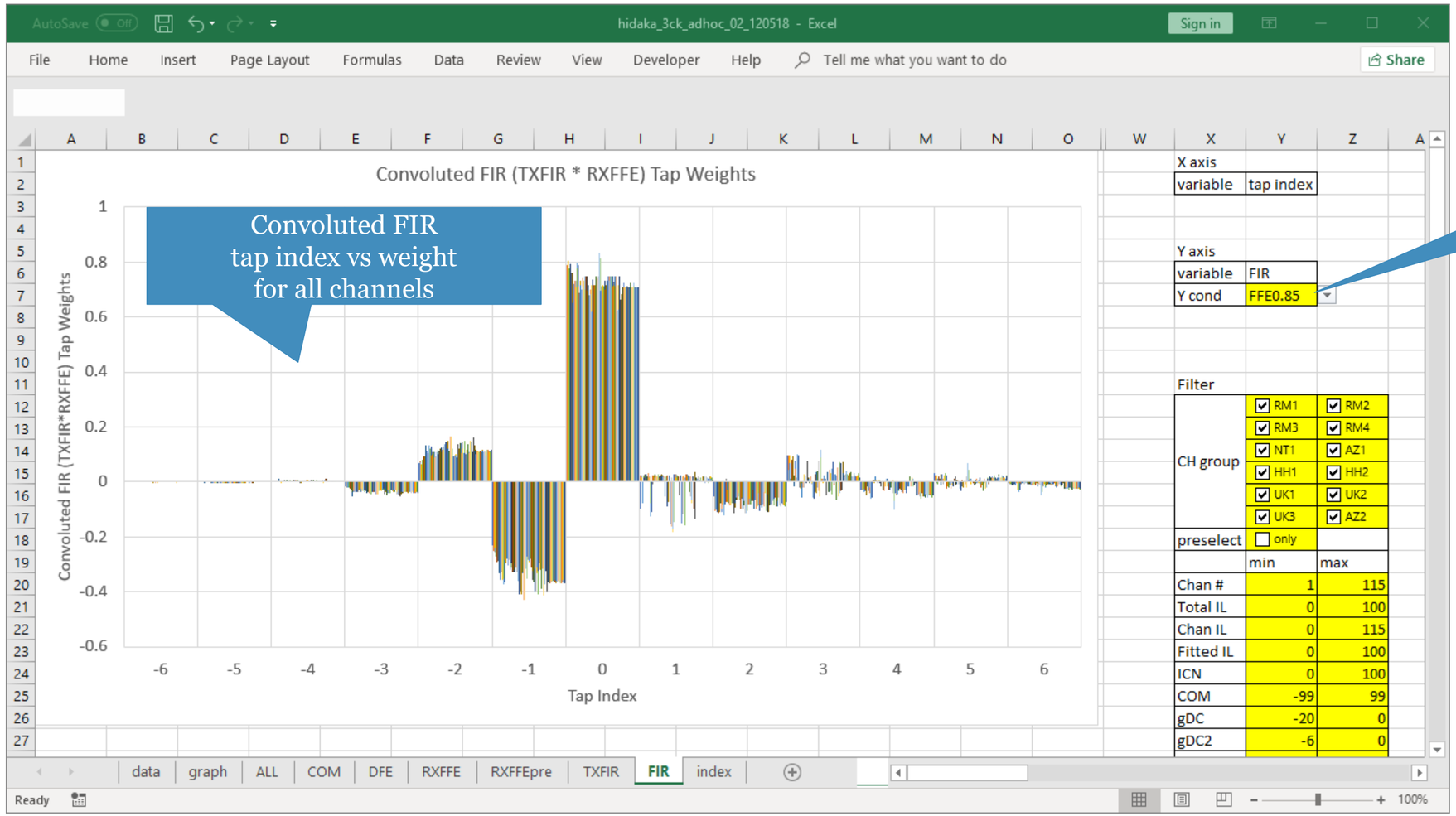
TXFIR tap index vs weight for all channels



Simulation condition of TXFIR tap weight in Y axis

Simulation conditions of Y axis:
DFE0.7, DFE0.85, DFE1.0,
PDFE0.7, PDFE0.85, PDFE1.0,
FFE0.7, FFE0.85,
CDFE0.7, CDFE0.85,
CPDFE0.7, CPDFE0.85,
CFFE0.7,
MDFE0.85, MFFE0.7

Sheet ‘FIR’ has Convoluted FIR Tap Weight Graph



Simulation condition of convoluted FIR tap weight in Y axis

Simulation conditions of Y axis:
DFE0.7, DFE0.85, DFE1.0,
PDFE0.7, PDFE0.85, PDFE1.0,
FFE0.7, FFE0.85,
CDFE0.7, CDFE0.85, CPDFE0.7, CPDFE0.85,
CFFE0.7,
MDFE0.85, MFFE0.7

- Convoluted FIR: effective FIR filter as convolution of TXFIR and RXFFE
  - Convoluted FIR[-6] = TXFIR[-3] * RXFFE[-3]
  - Convoluted FIR[-5] = TXFIR[-3] * RXFFE[-2] + TXFIR[-2] * RXFFE[-3]
  - Convoluted FIR[-4] = TXFIR[-3] * RXFFE[-1] + TXFIR[-2] * RXFFE[-2] * TXFIR[-1] * RXFFE[-3]
  - and so on

Back up

Detail COM Parameters (DFE0.7)

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	[1.1e-4 1.1e-4]	nF	[TX RX]
z_p select	2		[test cases to run]
z_p (TX)	[12 30; 1.8 1.8; 0 0 ; 0 0]	mm	[test cases]
z_p (NEXT)	[12 30; 1.8 1.8; 0 0 ; 0 0]	mm	[test cases]
z_p (FEXT)	[12 30; 1.8 1.8; 0 0 ; 0 0]	mm	[test cases]
z_p (RX)	[12 30; 1.8 1.8; 0 0 ; 0 0]	mm	[test cases]
C_p	[0.8e-4 0.8e-4]	nF	[TX RX]
C_v	[0 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.41	V	
A_fe	0.41	V	
A_ne	0.6	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.3:0.015:0]		[min:step:max]
c(-2)	[0:.015:0.105]		[min:step:max]
c(-3)	[-0.105:0.015:0]		[min:step:max]
c(-4)	[0]		[min:step:max]
c(1)	[-0.15:0.05:0]		[min:step:max]
N_b	20	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
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	
ffe_pre_tap_len	**0**	UI	
ffe_post_tap_len	0	UI	
Include PCB	0	logical	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	\results\100GEL_WG_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR2_ev al1_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	1000	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	**0.18**	
fixture delay time	0	
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	8.20E-09	V^2/GHz
SNR_TX	32.5	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 1.0404e-3 4.201e-4]	
package_tl_tau	6.325E-03	ns/mm
package_Z_c	[87.5 87.5; 92.5 92.5; 100 100; 100 100]	Ohm (tdr sel)

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	90	Ohm
z_bp (TX)	*115*	mm
z_bp (NEXT)	*115*	mm
z_bp (FEXT)	*115*	mm
z_bp (RX)	*115*	mm