



COM Simulation for 100G KR/CR Channels (update)

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Yasuo Hidaka, Phil Sun

Credo Semiconductor

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

- $\text{main_min} = 0.7$, $\text{pre1_max} = 0.3$, $\text{post1_max} = 0.3$, $\text{tapn_max} = 0.125$

▪ RX CTLE

- $\text{gDC} \in [-20,0]$, $\text{gDC2} \in [-6,0]$

▪ TX FIR tap

- $c(-3) \in [-0.105,0]$, $c(-2) \in [0,+0.105]$, $c(-1) \in [-0.3,0]$, $c(1) \in [-0.15,0]$

– 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

▪ $C_d = 110\text{fF}$, $C_p = 70\text{fF}$, $R_d = 50\Omega$

➤ Noise, jitter

▪ $\eta_0 = 8.20\text{E-}9\text{V}^2/\text{GHz}$, $\text{SNR}_{\text{TX}} = 32.5\text{dB}$, $\sigma_{\text{RJ}} = 0.01\text{UI}$, $A_{\text{DD}} = 0.02\text{UI}$, $R_{\text{LM}} = 0.95$

➤ 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)

The screenshot shows an Excel spreadsheet with the following callouts and features:

- Expand / collapse non-representative channels:** Callout pointing to the left side of the spreadsheet.
- Expand / collapse detail channel properties such as Insertion Loss (only Note is shown when collapsed):** Callout pointing to the 'Note' column.
- Expand / collapse detail sim results (only COM is shown when collapsed):** Callout pointing to the 'COM' columns.
- Cross reference channel # to previous presentations:** Callout pointing to the 'Cross ref channel #' header.
- Simulation condition:** Callout pointing to the 'Simulation condition' text in the spreadsheet.
- Label of simulation condition:** Callout pointing to the 'Label of simulation condition' text in the spreadsheet.
- Channel # with a hyperlink to reference document:** Callout pointing to the 'CH#' column containing hyperlinks.
- Notes for representative channels (add/clear the cell to change selection of representative channels):** Callout pointing to the 'Note' column.

| CH# | 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 [1] | DFE [20] | CTLE DC gain gDC | CTLE DC gain gDC2 | Detail FOM | COM | COM |
|-----|--|------------------------|------------------|-------------------------|--------------|----------|----------|-------------------------------|--------|------------|----------|------------------|-------------------|------------|--------|--------|
| 1 | Z0d_100_14p25in_2dBpi_meg6_rtf | 40.52 | 27.98 | 28.01 | 0.03 | 44.15 | 0.00 | | 3.5305 | 0 | 0.013858 | -19 | -2 | 15.3986 | 4.1943 | 4.2225 |
| 2 | Z0d_100_206in_0p13dBpi_twinax26_smooth | 40.52 | 27.98 | 27.98 | 0.00 | 100.00 | 0.00 | | 3.2609 | 0 | 0.011243 | -18 | -4 | 14.8651 | 3.6752 | 3.6487 |
| 3 | CaBP_BGAVia_Opt1_24dB_THRU | 35.89 | 23.33 | 23.79 | 0.23 | 30.76 | 0.00 | | 4.642 | 0 | 0.010409 | -15 | -4 | 15.5101 | 4.6272 | 4.6272 |
| 4 | CaBP_BGAVia_Opt1_28dB_THRU | 38.70 | 27.15 | 27.50 | 0.23 | 30.76 | 0.00 | High loss, smooth | 3.3371 | 0 | 0.012565 | -18 | -4 | 14.3765 | 3.4397 | 3.4397 |
| 7 | CaBP_BGAVia_Opt2_28dB_THRU | 38.70 | 27.15 | 27.50 | 0.23 | 30.76 | 0.00 | High loss, smooth | 3.596 | 0 | 0.009364 | -16 | -4 | 14.5225 | 3.7819 | 3.7284 |
| 14 | G1112_Thru_Ortho | | | | | | | Low loss, high ILD | 4.7464 | 0 | 0.005682 | -12 | -3 | 15.8349 | 4.7464 | 4.7464 |
| 15 | B56_Thru_CbIBP | | | | | | | Low loss, high ILD | 3.7551 | 0 | 0.02033 | -13 | -3 | 14.9504 | 3.8764 | 3.8764 |
| 21 | BKP_16dB_0p575m_more_is | | | | | | | oward's choice 1 (reflection) | 4.2084 | 0 | 0.046412 | -9 | -2 | 15.049 | 4.2084 | 4.2084 |
| 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)

(Updated)

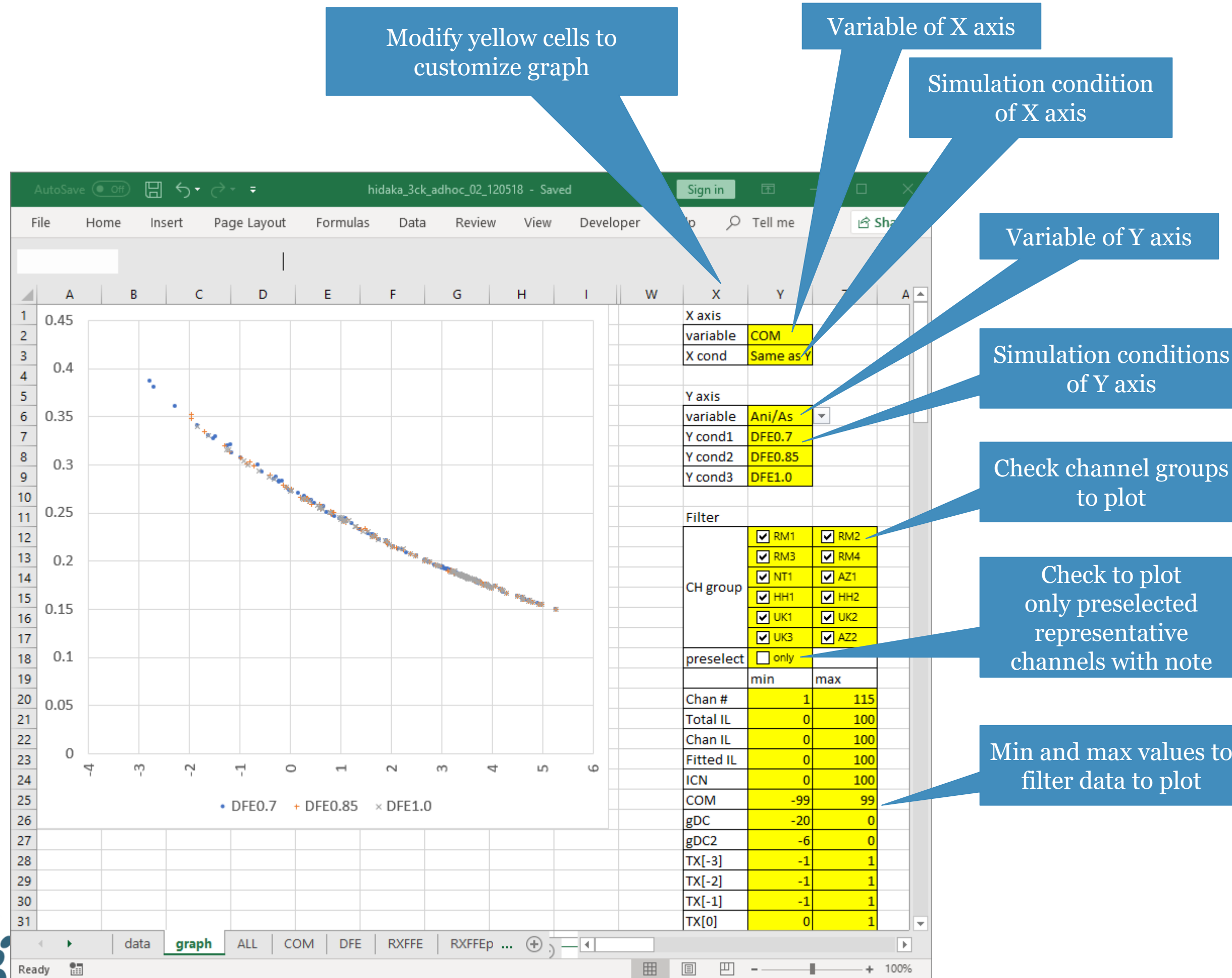
| CH# | COM | TX FIR [-3] | TX FIR [-2] | TX FIR [-1] | TX FIR [0] | TX FIR [1] | DFE [20] | CTLE DC gain gDC | CTLE DC gain gDC2 | As (mV) | Ani (mV) | RSS_DFE4 | $\sigma_{RJ} \sigma_X \sqrt{\sum h_J^2} / As$ | $\sigma(\eta_{noise}) / As$ | σ_{TX} / As | σ_G / As | $\sigma(p_{DD}) / As$ | $\sigma(p_n) / As$ | $\sigma(ISI) / As$ | $\sigma(XT) / As$ | Ani / As | FOM |
|-----|--------|-------------|-------------|-------------|------------|------------|----------|------------------|-------------------|---------|----------|----------|---|-----------------------------|--------------------|-----------------|-----------------------|--------------------|--------------------|-------------------|----------|---------|
| 1 | 3.5305 | -0.015 | 0.06 | -0.225 | 0.7 | 0 | 0.013858 | -2 | 2.6831 | 0.72 | 0.5047 | 0.077979 | 0.030322 | 0.11359 | 0.074886 | 0.139393 | 0.060402 | 0.15173 | 0.07560 | 0 | 0.169522 | 14.8651 |
| 2 | 3.2609 | 0 | 0.03 | -0.18 | 0.79 | 0 | 0.009364 | -4 | 2.6831 | 0.72 | 0.47799 | 0.018617 | 0.029861 | 0.127633 | 0.074887 | 0.15096 | 0.059585 | 0.16289 | 0.078326 | 0 | 0.18002 | 14.8651 |
| 3 | 4.642 | 0 | 0.03 | -0.18 | 0.79 | 0 | 0.009364 | -4 | 2.6831 | 0.72 | 0.59992 | 0.078717 | 0.03131 | 0.090469 | 0.074885 | 0.121544 | 0.061456 | 0.136592 | 0.078124 | 0.033265 | 0.177735 | 15.5101 |
| 4 | 3.3371 | 0 | 0.03 | -0.195 | 0.775 | 0 | 0.012565 | -18 | -4 | 2.685 | 0.49128 | 0.023464 | 0.030971 | 0.125182 | 0.074886 | 0.149122 | 0.061456 | 0.161227 | 0.032848 | 0.032848 | 0.184345 | 15.5101 |
| 7 | 3.596 | -0.015 | 0.06 | -0.225 | 0.7 | 0 | 0.009364 | -16 | -4 | 2.6831 | 0.47688 | 0.070575 | 0.03208 | 0.125184 | 0.074887 | 0.149361 | 0.064153 | 0.162353 | 0.06135 | 0.038347 | 0.177735 | 14.5225 |
| 14 | 4.7464 | -0.03 | 0.075 | -0.27 | 0.625 | 0 | 0.005682 | -12 | -3 | 2.6749 | 0.6159 | 0.0968 | 0.029825 | 0.090067 | 0.074885 | 0.12087 | 0.059769 | 0.15173 | 0.083001 | 0.158946 | 0.158946 | 15.8349 |

$$\sigma_G^2 = \sigma_{IX}^2 + \sigma_{RJ}^2 \sigma_X^2 \sum_n h_J^2(n) + \eta_0 \int_0^\infty |H_r(f) H_{ctf}(f)|^2 df$$

$$p_n(y) = p_G(y) * p_{DD}(y)$$

Sheet 'graph' has General Interactive Graphs

(Updated)



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

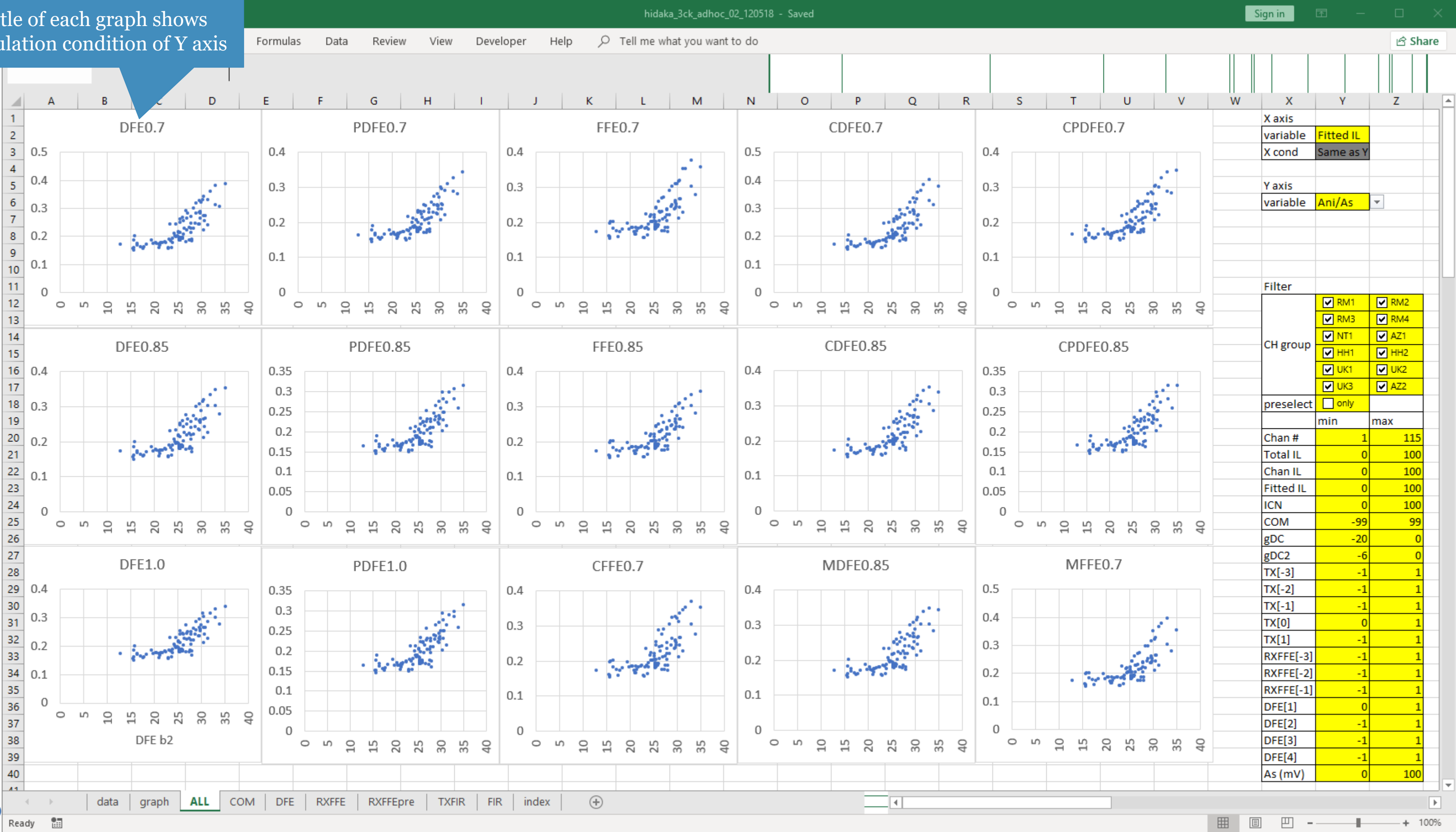
Variables depending on simulation condition:
 COM, FOM, gDC, gDC2,
 TX[-3:1], RXFFE[-3:20], DFE[1:20],
 As (mV), Ani (mV), **RSS_DFE4 (new)**, Ani/As,
 $\sigma(XT)/As$, $\sigma(ISI)/As$, $\sigma(p_n)/As$, $\sigma(p_DD)/As$,
 σ_G/As , σ_RJ , $\sigma_X \sqrt{\sum(h_J^2)}$ / As,
 $\sigma(\eta_0noise) / As$, 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



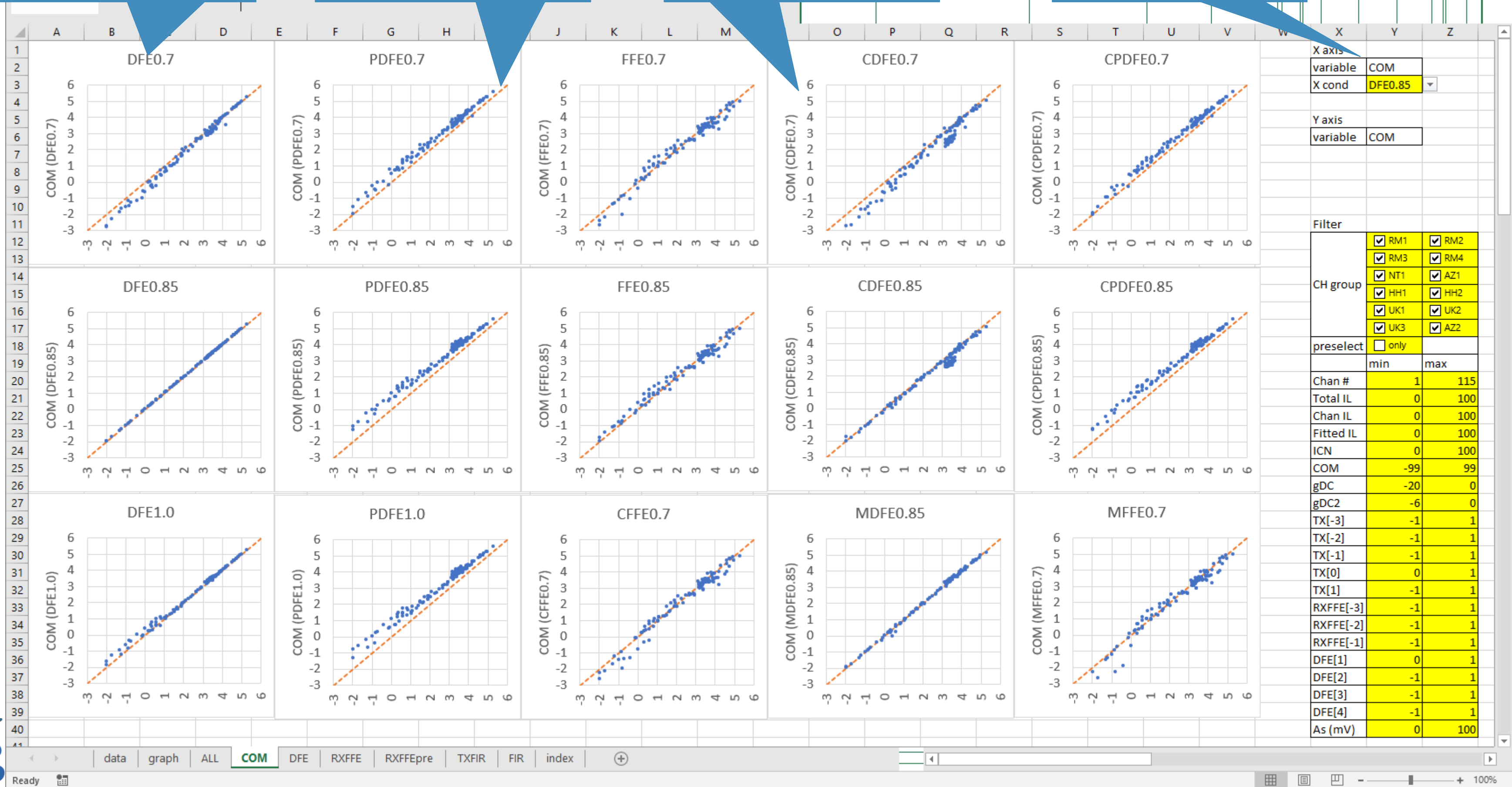
Sheet 'COM' has COM vs COM graphs

Title of each graph shows simulation condition of Y axis

Reference line is added

Range is fixed to [-3,+6]

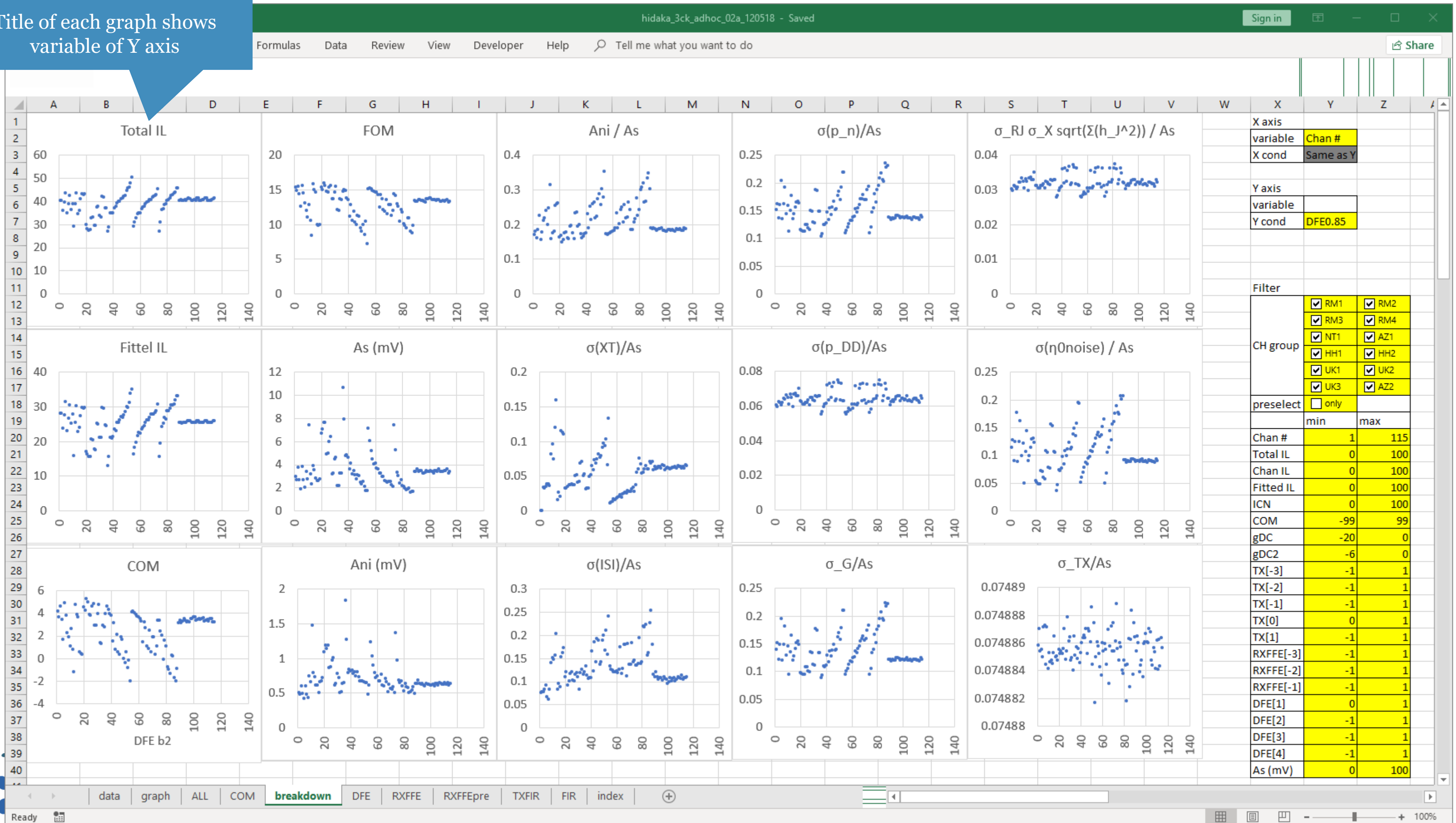
X and Y variables are fixed as COM



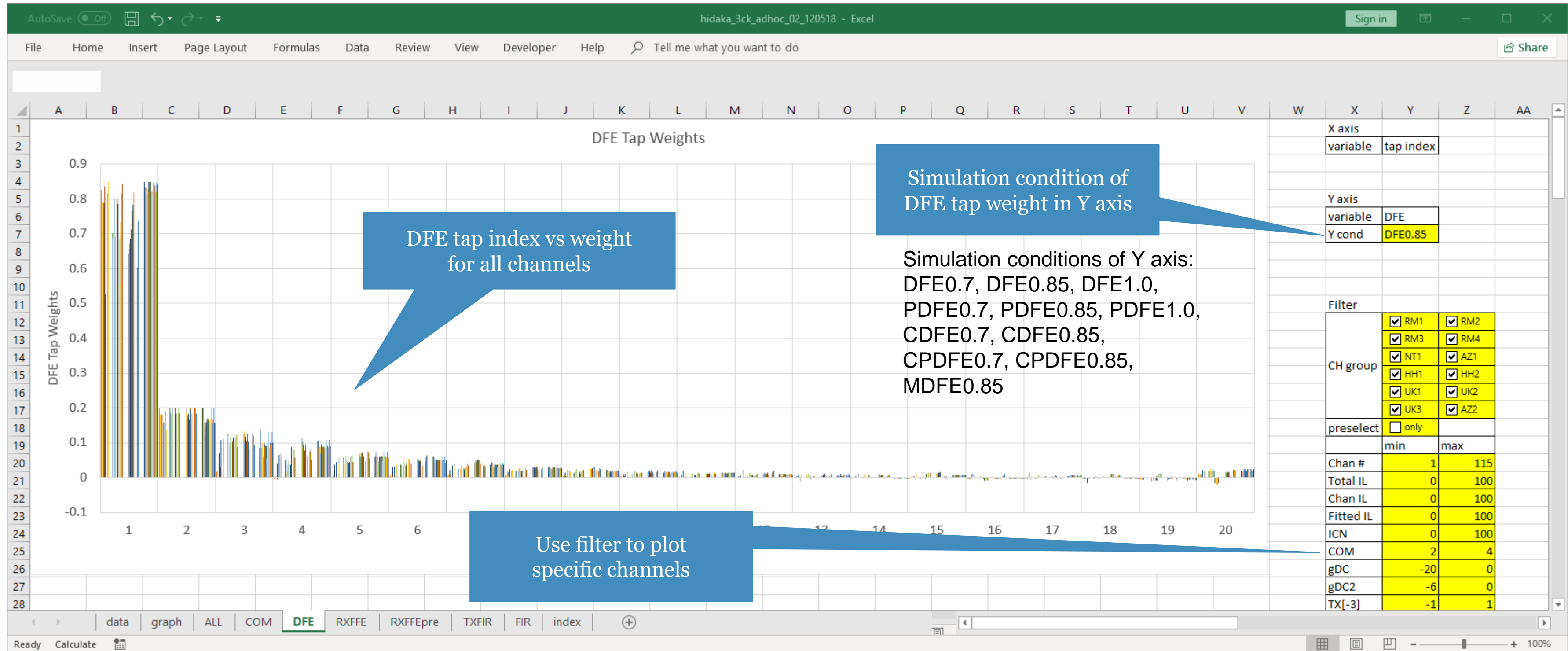
Sheet 'breakdown' shows components of COM

(New)

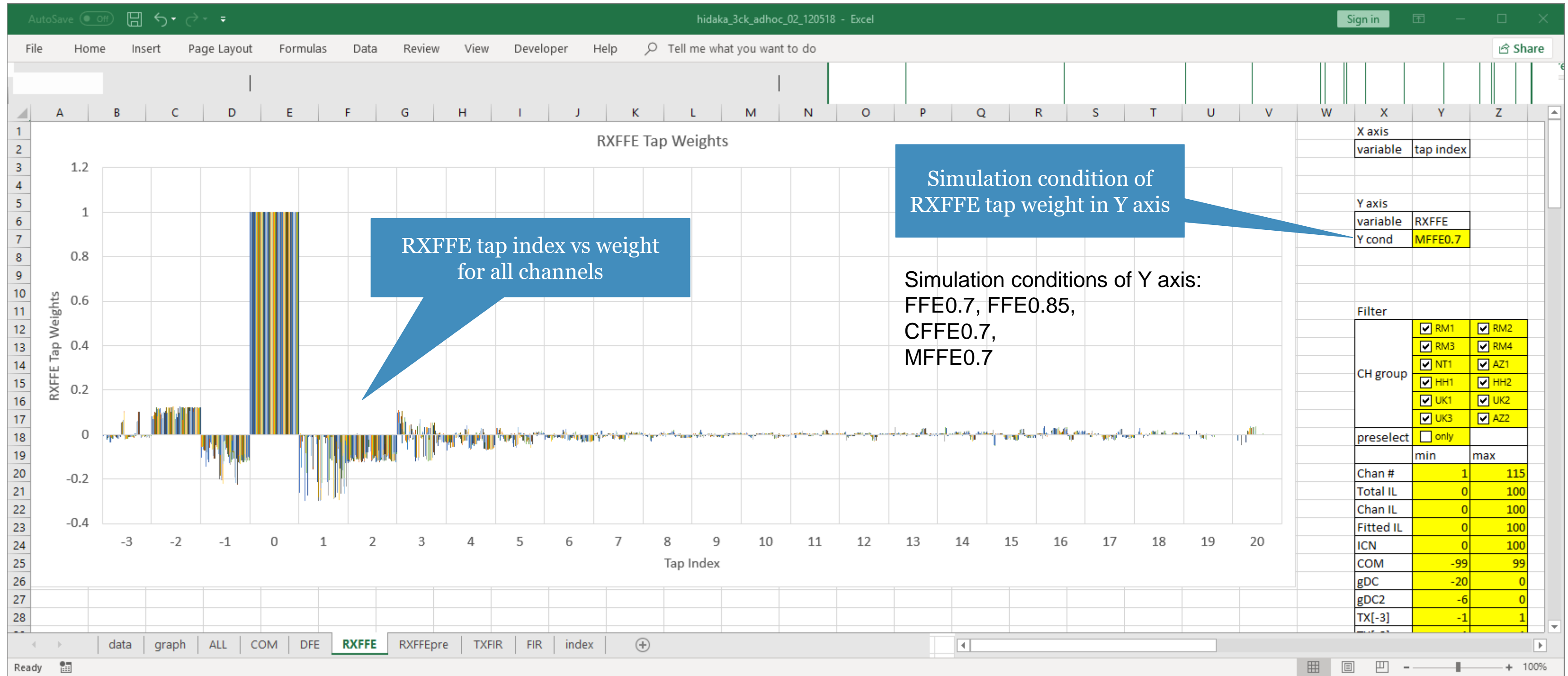
Title of each graph shows variable of Y axis



Sheet 'DFE' has DFE Tap Weight Graph

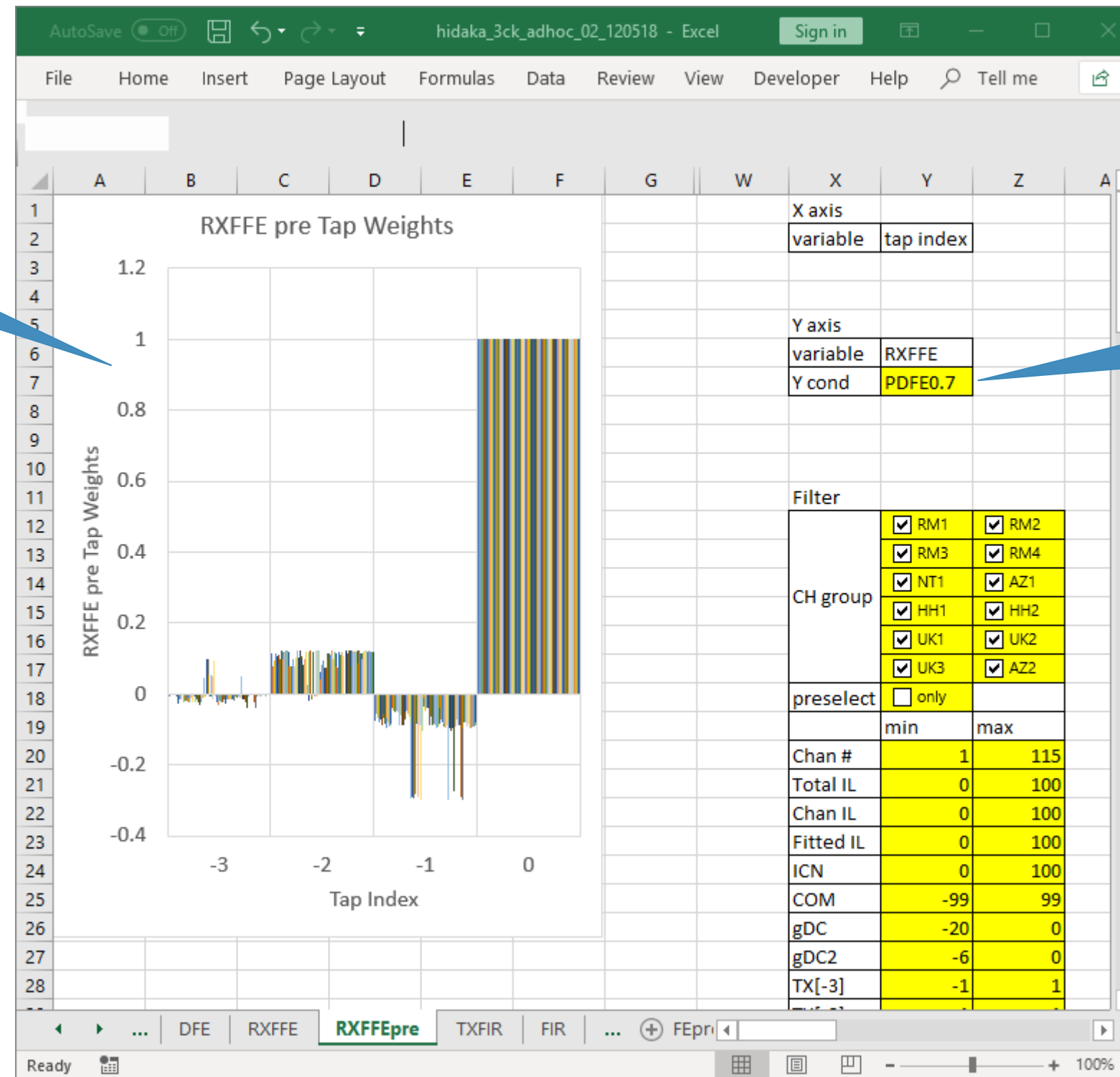


Sheet 'RXFFE' has RXFFE Tap Weight Graph



Sheet 'RXFFEpre' has RXFFE pre Tap Weight Graph

RXFFE pre-tap index vs weight for all channels

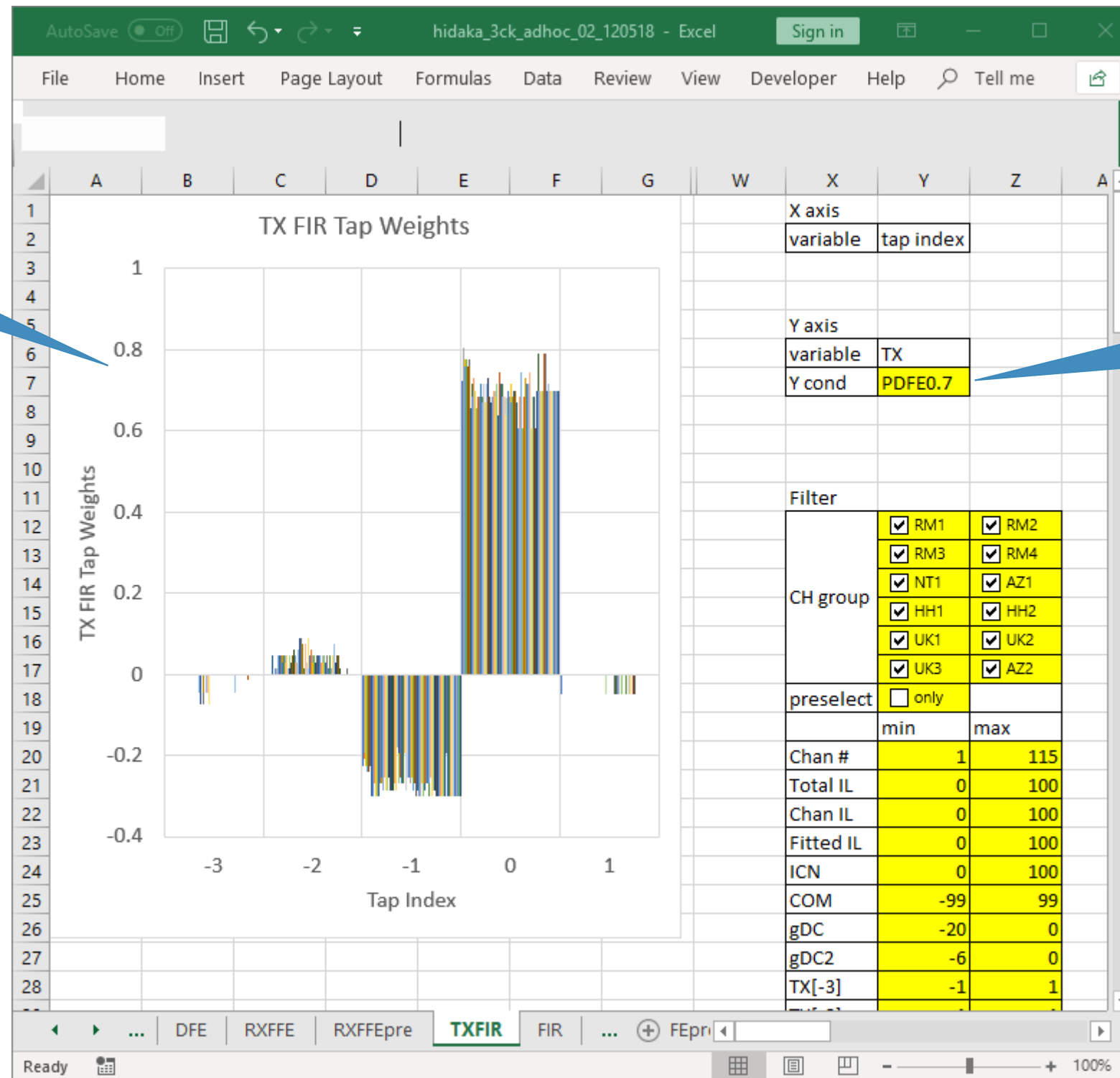


Simulation condition of RXFFE pre-tap weight in Y axis

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

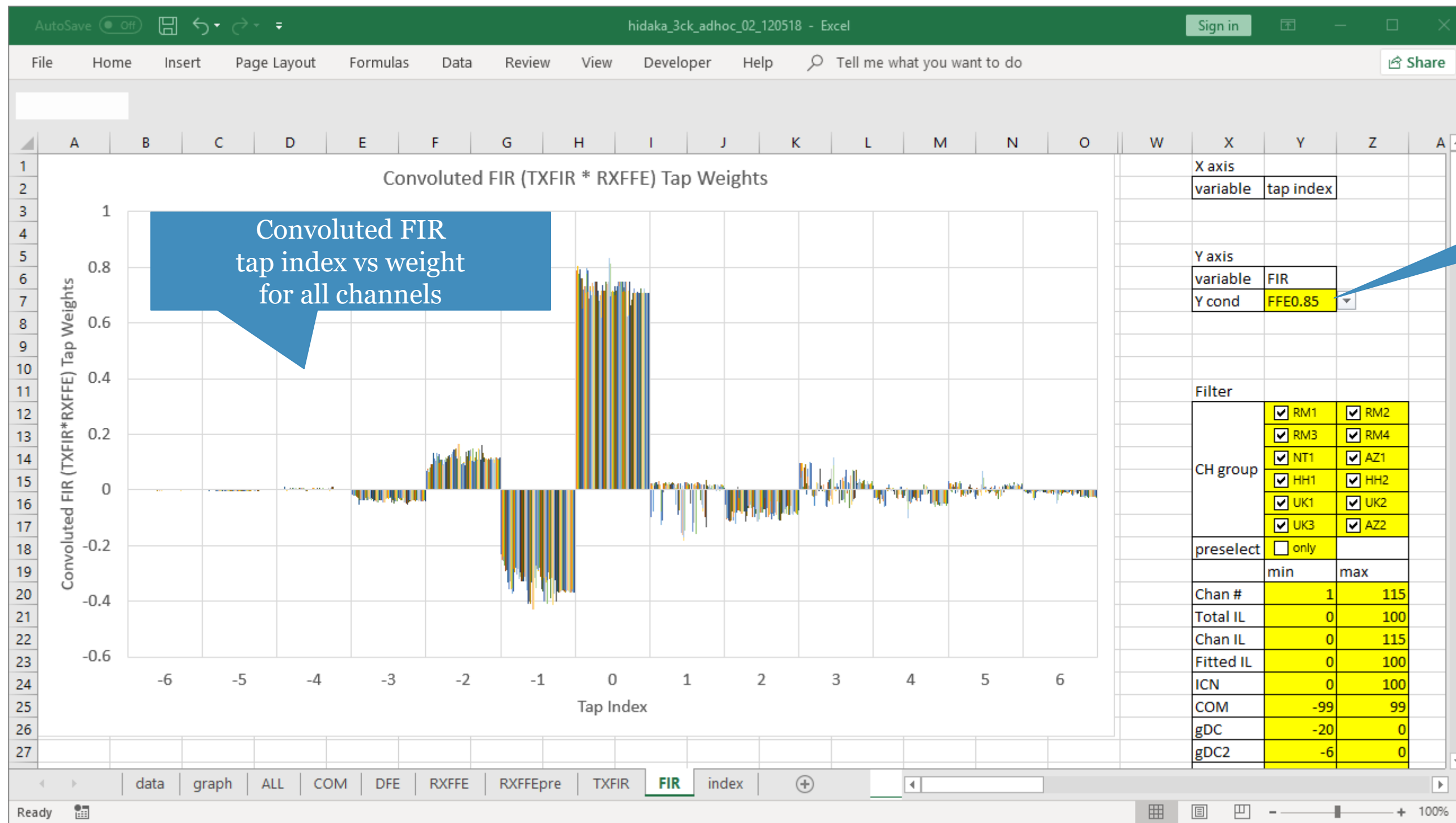
TXFIR tap index vs weight for all channels



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

- $\text{Convoluted FIR}[-6] = \text{TXFIR}[-3] * \text{RXFFE}[-3]$
- $\text{Convoluted FIR}[-5] = \text{TXFIR}[-3] * \text{RXFFE}[-2] + \text{TXFIR}[-2] * \text{RXFFE}[-3]$
- $\text{Convoluted FIR}[-4] = \text{TXFIR}[-3] * \text{RXFFE}[-1] + \text{TXFIR}[-2] * \text{RXFFE}[-2] + \text{TXFIR}[-1] * \text{RXFFE}[-3]$
- 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; 00 ; 00] | mm | [test cases] |
| z_p (NEXT) | [12 30; 1.8 1.8; 00 ; 00] | mm | [test cases] |
| z_p (FEXT) | [12 30; 1.8 1.8; 00 ; 00] | mm | [test cases] |
| z_p (RX) | [12 30; 1.8 1.8; 00 ; 00] | mm | [test cases] |
| C_p | [0.8e-4 0.8e-4] | nF | [TX RX] |
| C_v | [00] | 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 |

