Two-Phase Grid Search for Fast COM Calculation

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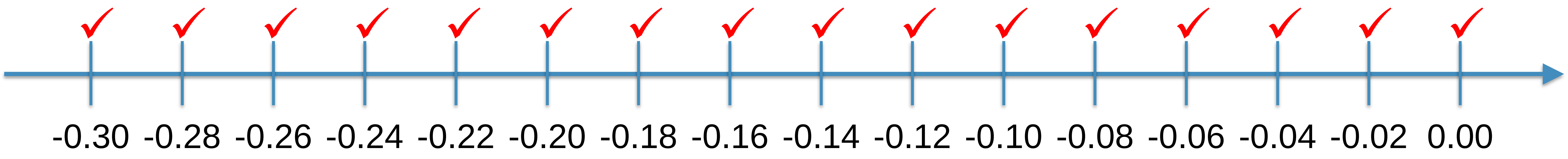
Introduction

- COM calculation time is mainly contributed by
  - Computation iteration for TX FIR taps, CTLE curves, low-frequency CTLE
  - FFE-based model needs extra computation for inversion of large matrix
    - For each grid of FOM optimization, inversion of NxN matrix is required for N-tap RX FFE
      - Computation cost of NxN matrix is $O(N^3)$

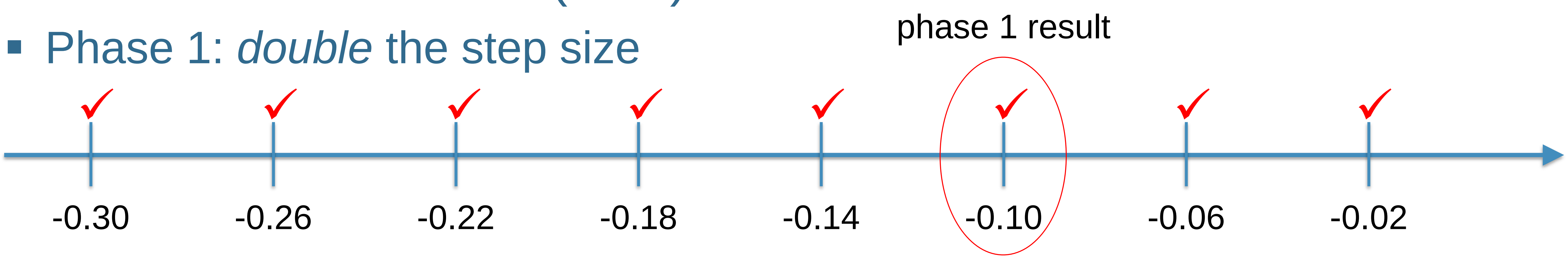
- We evaluated a two-phase grid search algorithm to look for much faster COM calculation

Two-Phase Grid Search for fast FOM Optimization

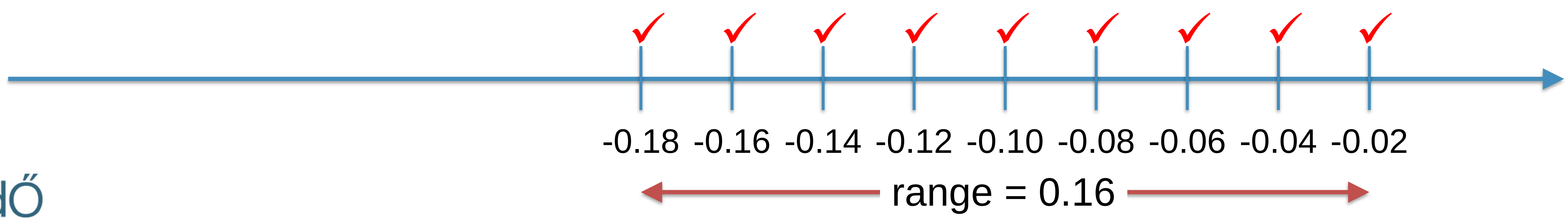
- Full-Grid Search (Conventional)
  - Check all values
  - Ex) min / step / max = -0.30 / 0.02 / 0.00



- Two-Phase Grid Search (New)
  - Phase 1: *double* the step size

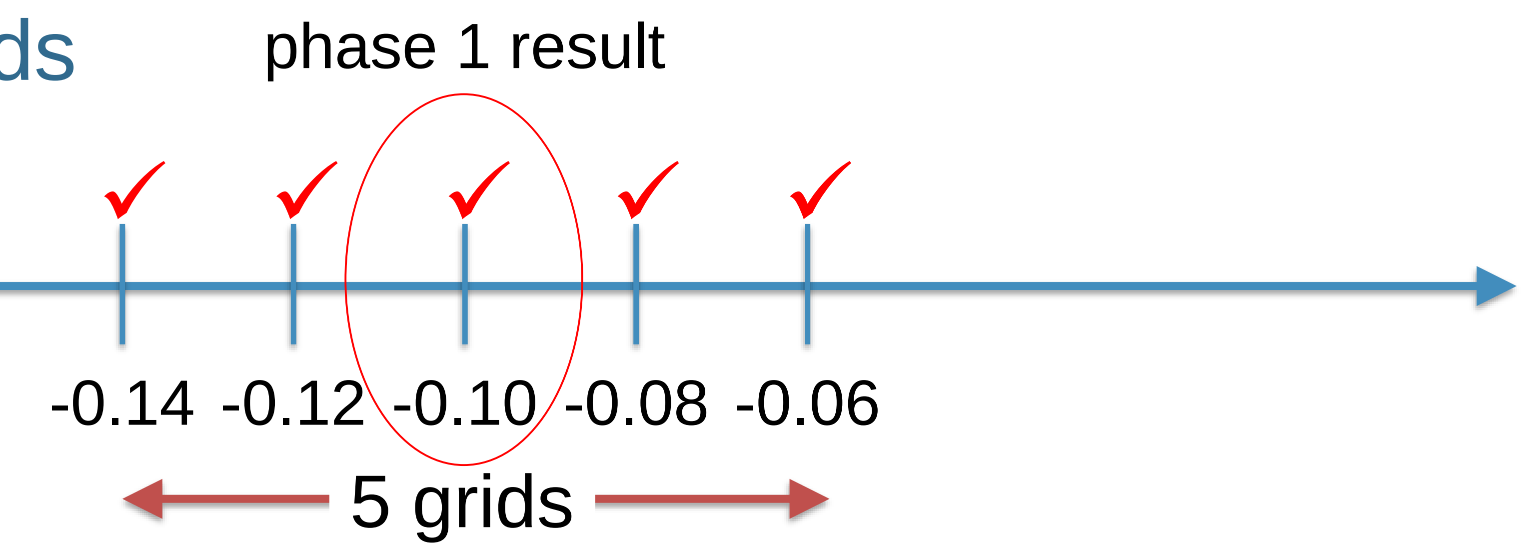


  - Phase 2: *half* the search range with the phase 1 result at the center

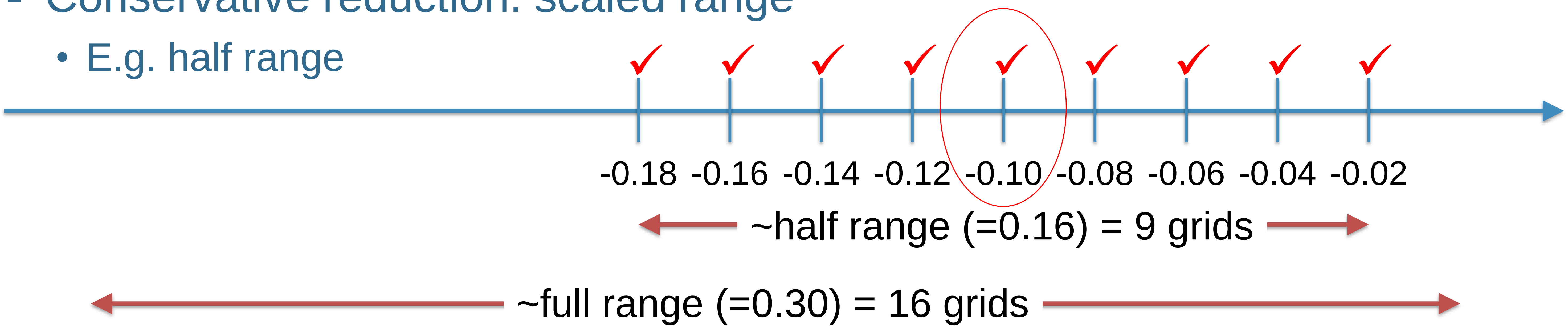


Aggressive vs Conservative Range Reduction in Phase 2

- Two possible schemes
  - Aggressive reduction: just a few grids
    - E.g. 5 grids



  - Conservative reduction: scaled range
    - E.g. half range



- We propose conservative reduction
  - Aggressive reduction may cause a result different from the full-grid search
    - In fact, we observe gDC of phase 1 is -16dB, whereas gDC of full-grid search is -11dB
      - To get the same result as the full-grid search, we need a quite wide range in phase 2

of Grids by Conservative Range Reduction

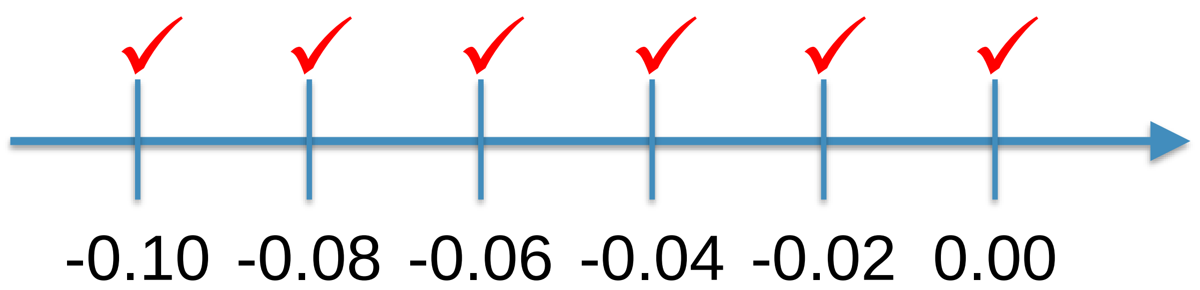
- For each parameter,
  - # of grids in phase 1 is about half, because of double step
  - # of grids in phase 2 is about half, because of half range
  - Hence, total # of grids for each parameter does not change from the full-grid search

- For multiple (e.g. 4) parameters,
  - Total # of grids in phase 1 is about $\left(\frac{1}{2}\right)^4 = \frac{1}{16}$ because of double step
  - Total # of grids in phase 2 is about $\left(\frac{1}{2}\right)^4 = \frac{1}{16}$ because of half range
  - Hence, total # of grids for 4 parameters is about $\left(\frac{1}{2}\right)^4 \times 2 = \frac{1}{8}$ of the full-grid search

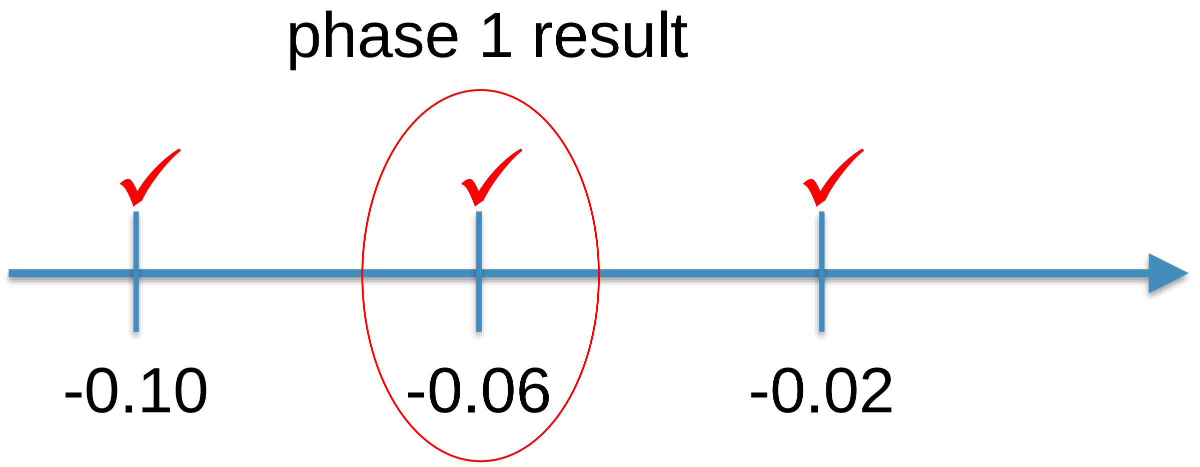
- Namely, although the # of grids for each parameter does not change, total # of grids for N parameters will reduce by a factor of $\frac{1}{2^{(N-1)}}$

Requirements for Min # of Grids and Options

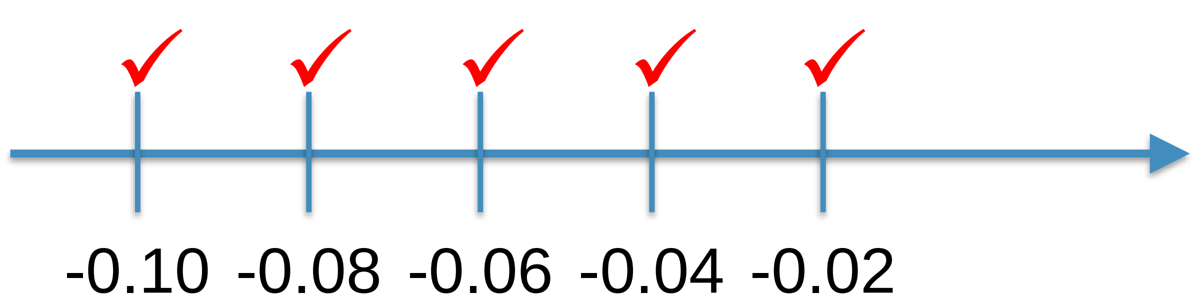
- We applied the algorithm only to parameters with ≥ 6 grids
  - With ≤ 5 grids (i.e. ≤ 4 segments), check all full grids in phase 1 and 2
  - Ex) min / step / max = -0.10 / 0.02 / 0.00 (example of min # of grids)



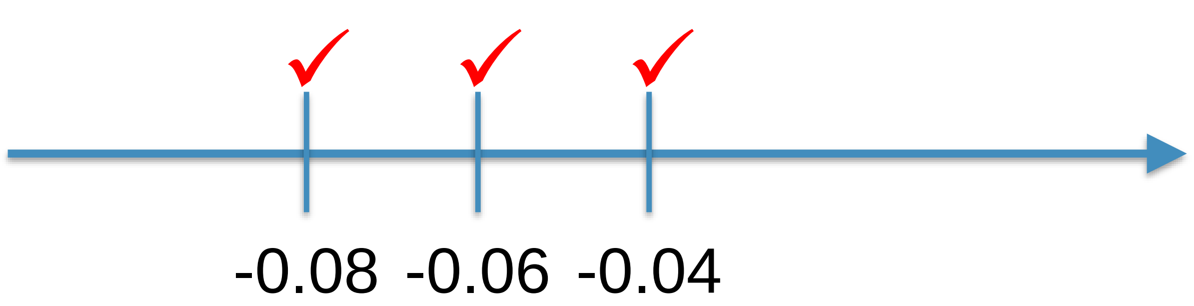
  - Phase 1 (double the step size)



  - Phase 2 with Option A: min 5 grid



  - Phase 2 with Option B: min 3 grid



Experimental Implementation

- In order to evaluate how close results we can get to the full-grid search, we experimentally implemented the algorithm as a wrapping function
  - The wrapping function calls the COM tool function for multiple times
    - For each phase
    - For each package length
  - It has unnecessary overhead
    - S-parameter files are loaded and analyzed for multiple times
    - COM value for phase 1 is unnecessarily calculated

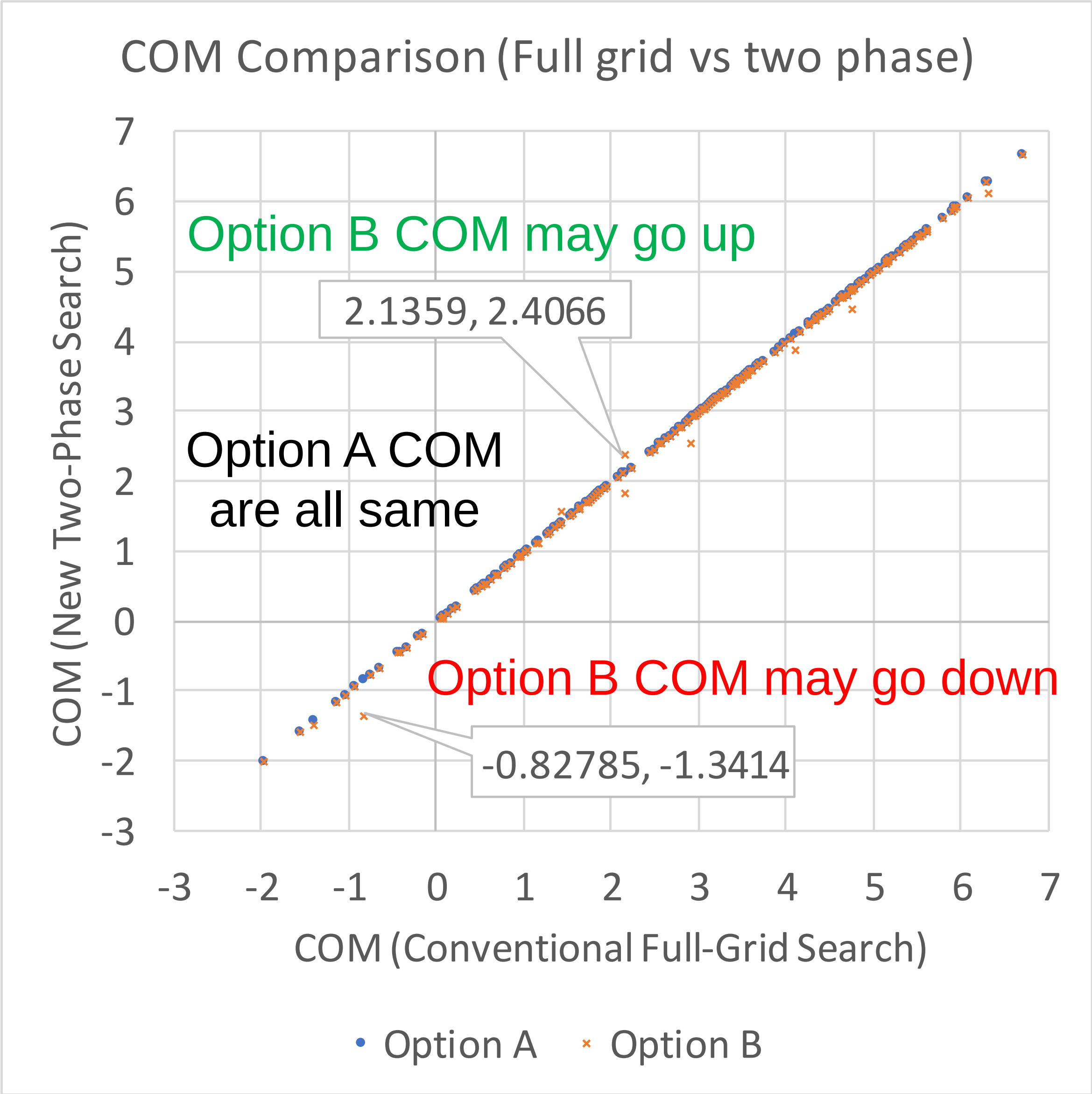
- Once we have consensus, we can work on the full implementation

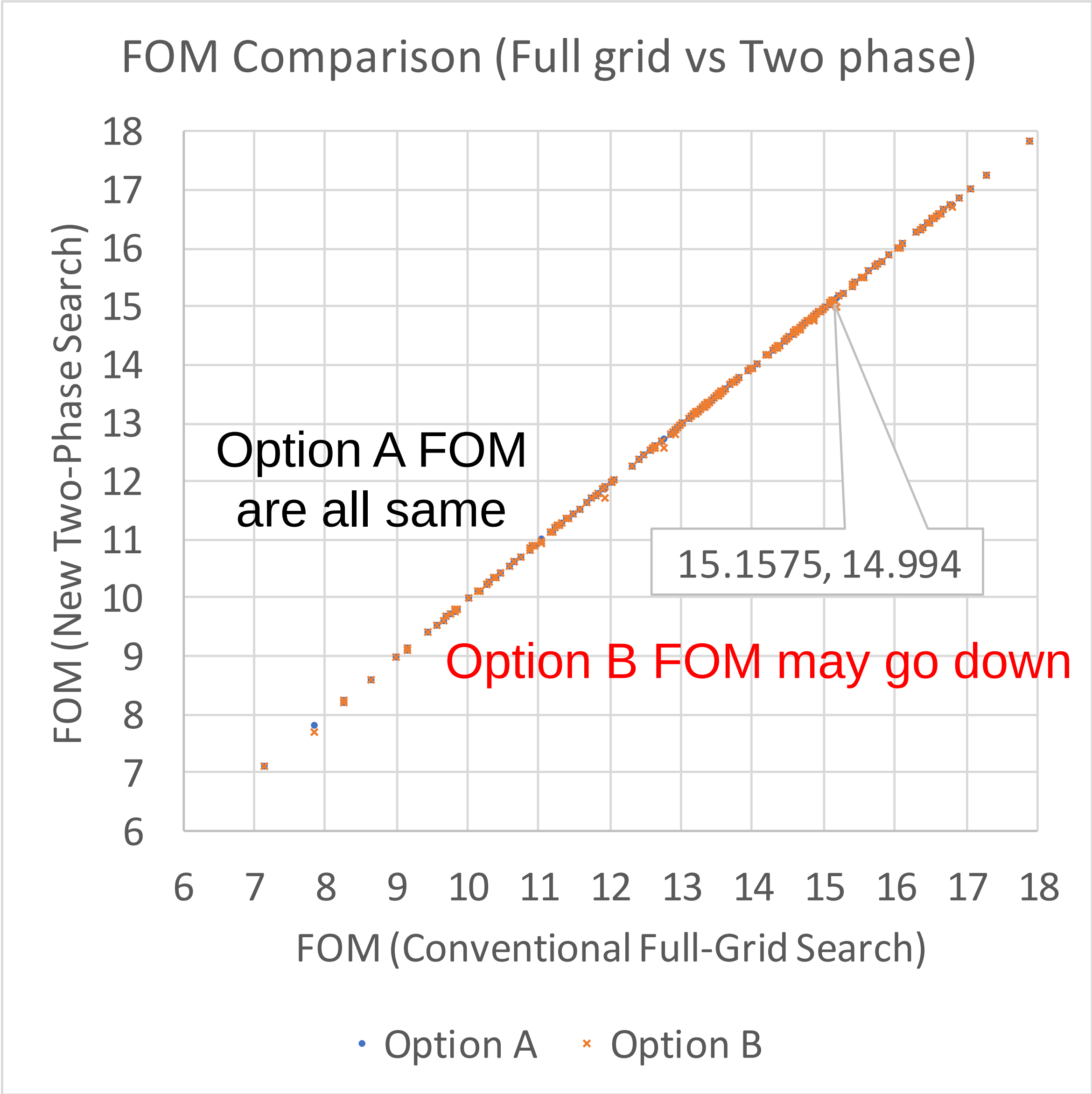
Evaluation Conditions

- Equalizer configuration
  - RX model
    - DFE-based model (b1max = 0.85, Nb=16 for all conditions, Nb=20/24/28 for limited conditions)
    - FFE-based model (b1max = 0.7, Nb=1, pre=3, post=16/20/24/28 for limited conditions)
  - TX FIR tap range
    - c(-3) ∈ [-0.06:0.02:0], c(-2) ∈ [0:0.02:0.12], c(-1) ∈ [-0.34:0.02:0], c(1) ∈ [-0.1:0.05:0]
    - c(0) ≥ 0.54
  - RX CTLE
    - gDC ∈ [-20:0], gDC2 ∈ [-6:0]
- Package Model (Tx and Rx)
  - z_p = 12mm or 30mm, C_d = 110fF, C_p = 80fF, R_d = 50Ω
- Noise, jitter
  - η_0=8.20E-9V^2/GHz, SNR_{TX}=33dB, σ_{RJ}=0.01UI, A_{DD}=0.02UI, R_{LM}=0.95
- Channels
  - Publicly available 115 KR/CR channels at web page (see the detail in the back up)
- COM Tool version
  - v2.54 (before Rich's speed up) and v2.56mod (after Rich's speed up)
    - V2.56mod is expected to have same results as v2.57
      - For v2.56mod, "break" was changed to "continue" according to Rich's intention of speed-up fix
- Computer used for evaluation
  - CPU Intel Core i5-8250U @ 1.60GHz 1.80GHz, Memory 8GB, OS Windows 10 Pro

Two-Phase Search vs Full-Grid Search

- Option A gave 100% same results as the full-grid search
- Option B gave 95% (219/230) same results as the full-grid search
  - COM went up in 3 cases by up to 0.27dB, and went down in 8 cases by up to 0.51dB
    - This is because EQs are optimized by FOM
      - FOM went down in 11 cases by up to 0.16dB, never went up

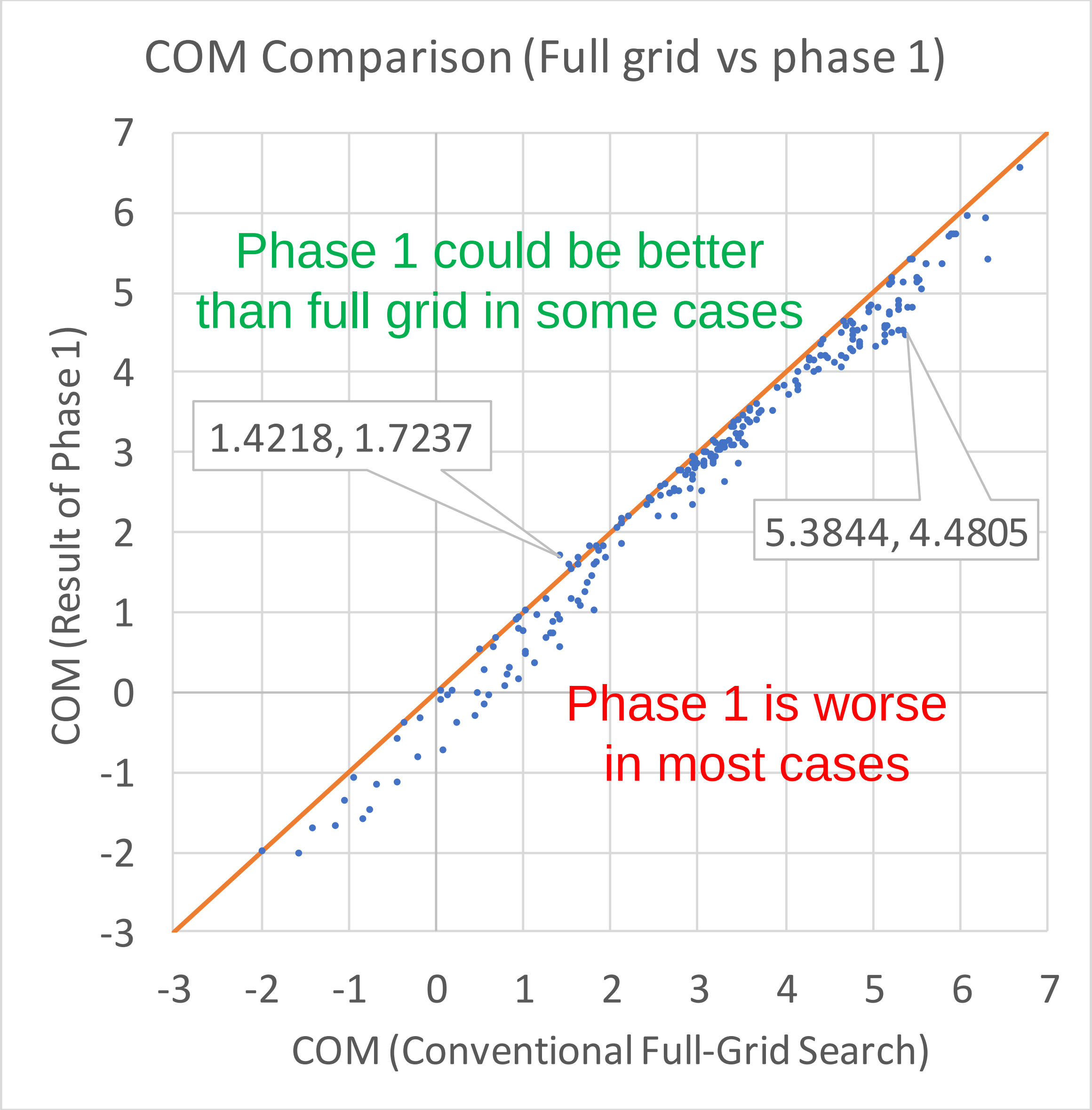


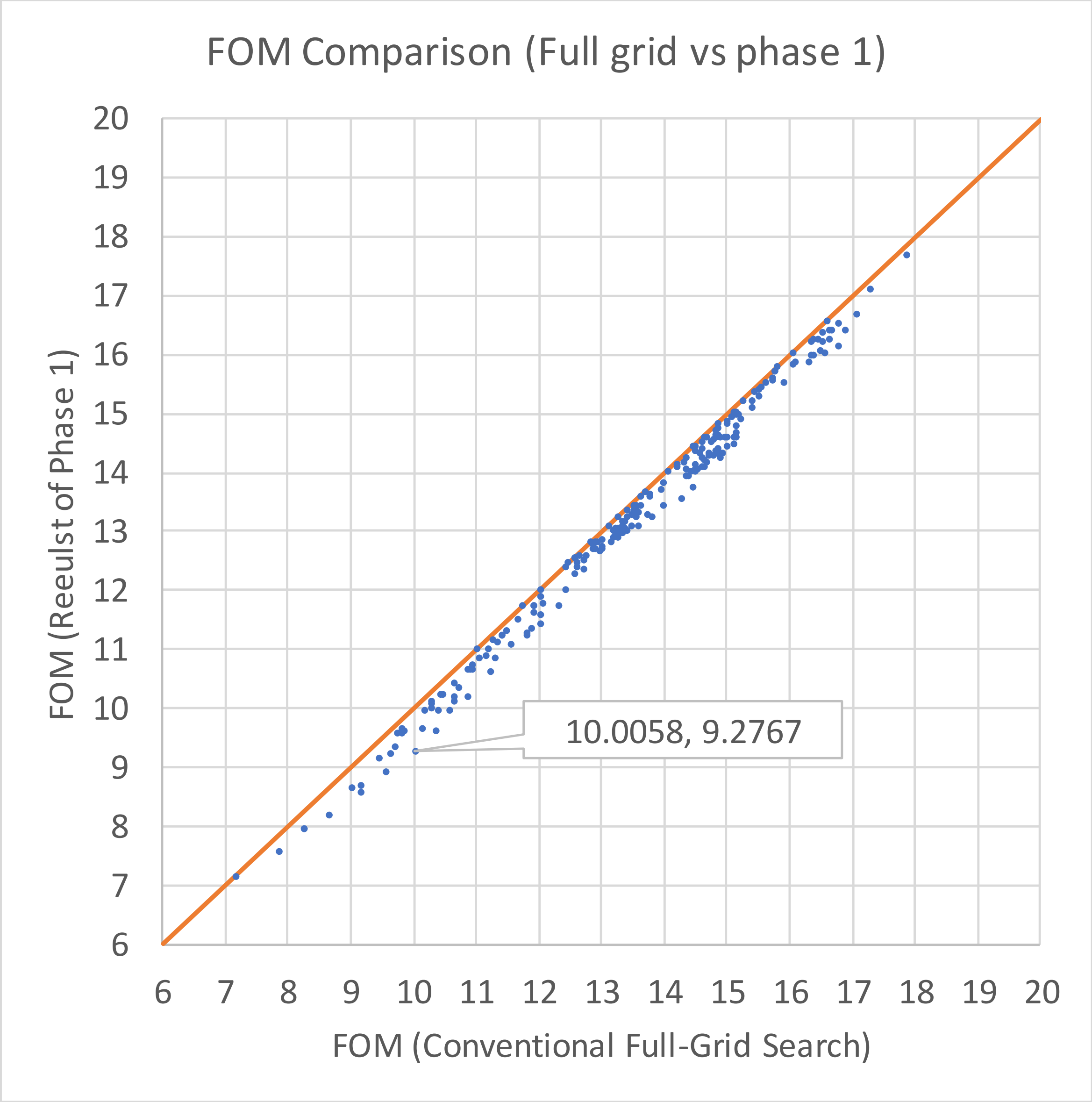


These results were completely same for v2.54 and v2.56mod

Phase 1 (i.e. double step) vs Full-Grid Search

- COM value of Full-Grid Search is not necessarily the best
  - In 7 out of 230 cases, phase 1 result was better by up to 0.3dB
  - In most (205 out of 230) cases, phase 1 result was worse by up to 0.9dB
- Statistically, the COM value is likely improved with a finer step, but this is not always the case





These results were completely same for v2.54 and v2.56mod

Discussion on Full-Grid Search: Do we really need it?

- Two-phase search gives COM value close to the full-grid search
  - We empirically verified that it is same for 230 cases with option A
    - Theoretically, two-phase search may be still sub optimal
- However, full-grid search does not necessarily give the best COM as well
  - Because EQ parameters are optimized by FOM
- With two-phase search, we may choose a higher COM value from results of phase 1 and phase 2
  - This COM value may be higher than COM value by the full-grid search
  - This option is not possible for the full-grid search, unless we optimize EQ parameters by COM instead of FOM
- Although two-phase search does not necessarily give the same result as the full-grid search, that is likely the case, and the phase 1 result may give a higher COM value than the full-grid search

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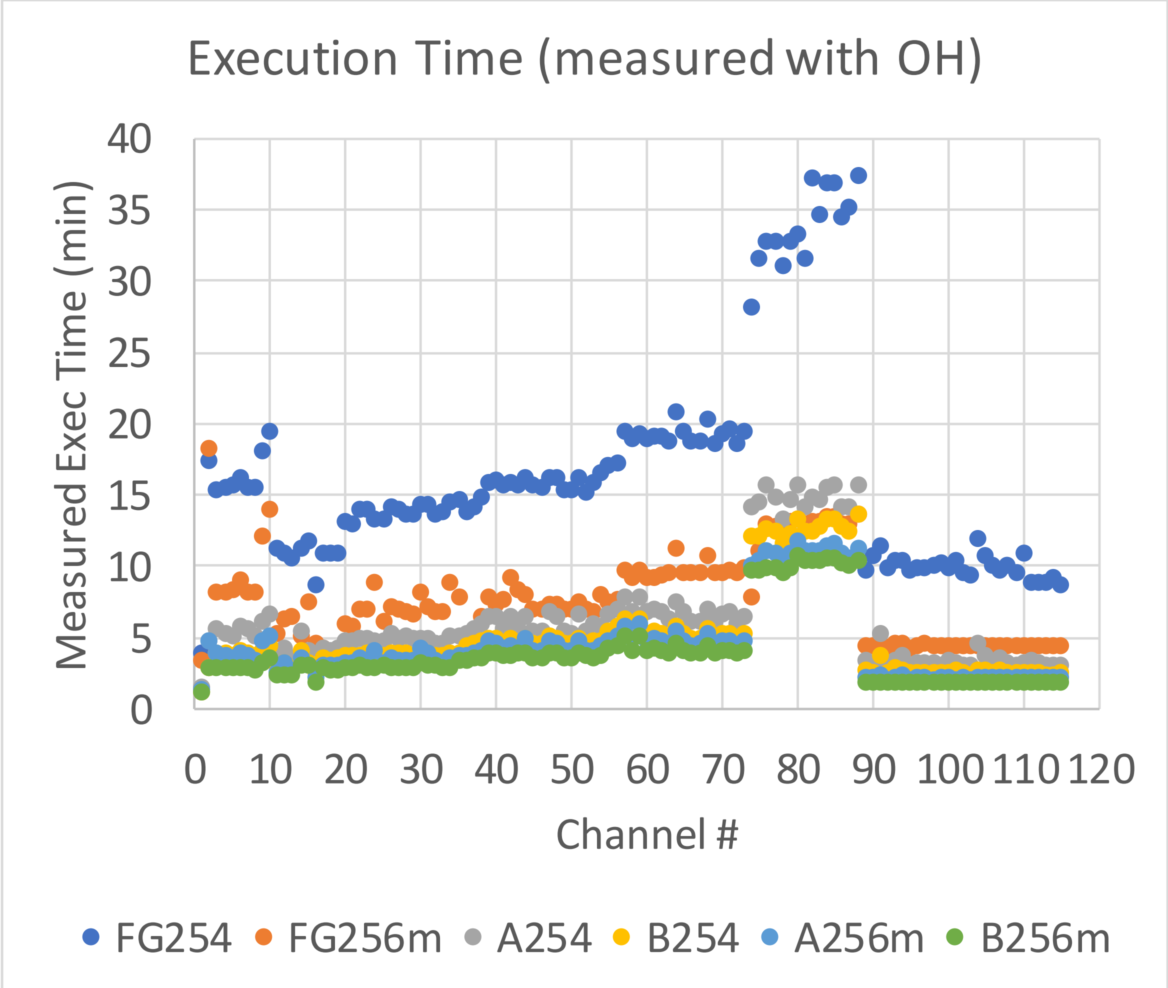
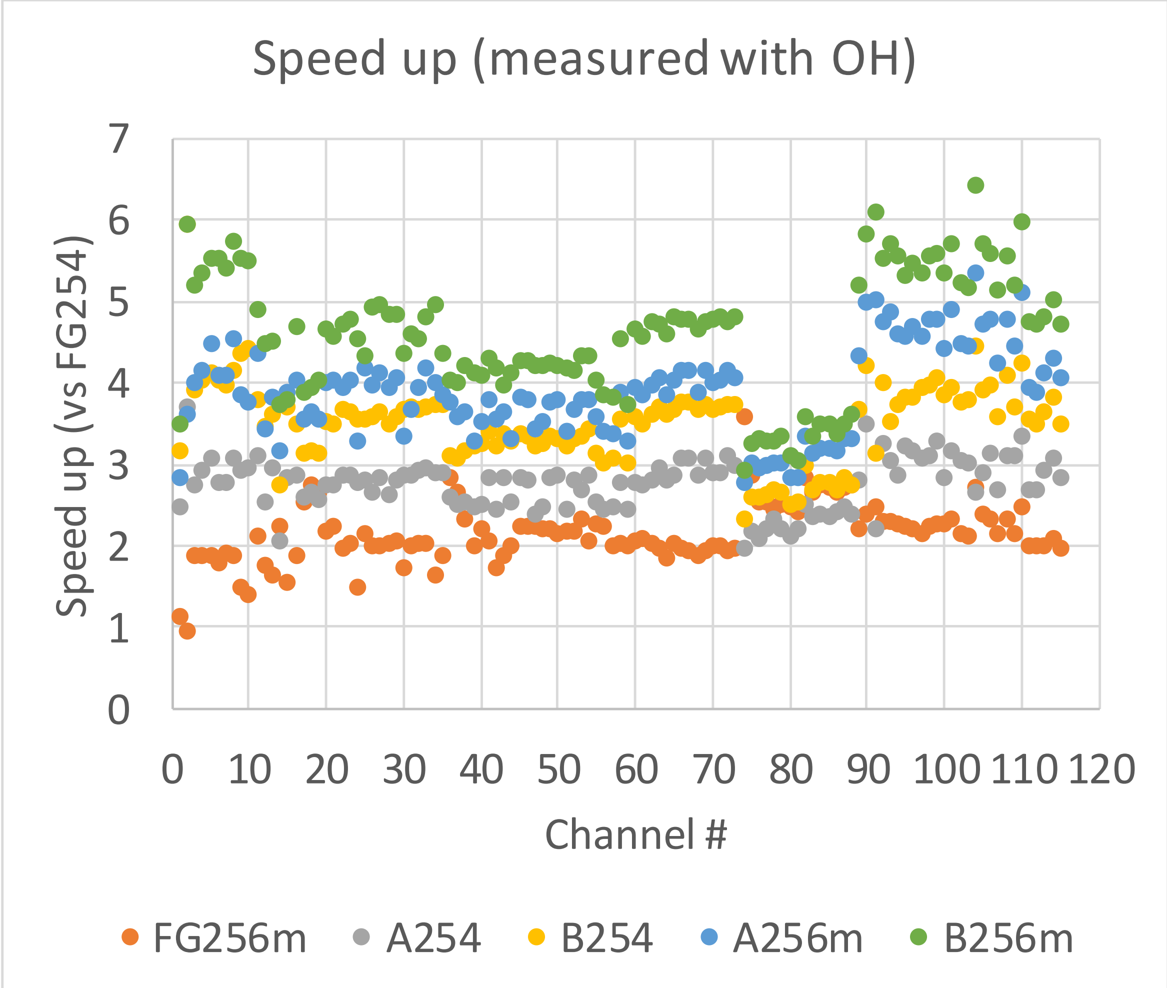
Measured Exec Time with Overhead

- Average speed up is 2.64x (option A) or 3.29x (option B) for v2.54
  - Or 3.66x (option A) or 4.22x (option B) when combined with Rich's speed up

	Measured Execution Time with Overhead (min)						Speed up (vs FG254)				
							by RM	by Two phase		Combined	
	FG254	FG256	A254	B254	A256m	B256m	FG256	A254	B254	A256m	B256m
max	37.47	18.22	15.70	13.63	11.74	10.76	3.59x	3.69x	5.96x	5.34x	6.41x
min	3.88	3.38	1.56	1.22	1.37	1.11	0.95x	1.98x	2.32x	2.79x	2.91x
average	16.56	7.70	6.27	5.04	4.52	3.93	**2.15x**	**2.64x**	**3.29x**	**3.66x**	**4.22x**





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Breakdown of Execution Time (v2.54)

- Measured execution time with overhead
  - Full grid
    994s

Load S4P files	FOM 12mm	COM 12mm	FOM 30mm	COM 30mm
40.0s	465.2s	6.6s	475.1s	7.0s

  - Option A
    376s (2.64x)

Load S4P files	P1 FOM 12mm	P1 COM 12mm	Load S4P files	P2 FOM 12mm	P2 COM 12mm	Load S4P files	P1 FOM 30mm	P1 COM 30mm	Load S4P files	P2 FOM 30mm	P2 COM 30mm
40.0s	39.8s	6.6s	40.0s	57.5s	6.6s	40.0s	39.5s	7.0s	40.0s	52.0s	7.0s

  - Option B
    302s (3.29x)

Load S4P files	P1 FOM 12mm	P1 COM 12mm	Load S4P files	P2 FOM 12mm	P2 COM 12mm	Load S4P files	P1 FOM 30mm	P1 COM 30mm	Load S4P files	P2 FOM 30mm	P2 COM 30mm
40.0s	39.8s	6.6s	40.0s	18.6s	6.6s	40.0s	39.6s	7.0s	40.0s	16.9s	7.0s

- Estimated execution time without overhead
  - Full grid
    994s

Load S4P files	FOM 12mm	COM 12mm	FOM 30mm	COM 30mm
40.0s	198.1s	6.5s	212.4s	6.8s

  - Option A
    242s (4.10x)

Load S4P files	P1 FOM 12mm	P2 FOM 12mm	COM 12mm	P1 FOM 30mm	P2 FOM 30mm	COM 30mm
40.0s	39.8s	57.5s	6.6s	39.5s	52.0s	7.0s

  - Option B
    168s (5.90x)

Load S4P files	P1 FOM 12mm	P2 FOM 12mm	COM 12mm	P1 FOM 30mm	P2 FOM 30mm	COM 30mm
40.0s	39.8s	18.6s	6.6s	39.6s	16.9s	7.0s

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Breakdown of Execution Time (v2.56mod)

- Measured execution time with overhead
  - Full grid
    462s (2.15x)

Load S4P files	FOM 12mm	COM 12mm	FOM 30mm	COM 30mm
38.5s	198.1s	6.5s	212.4s	6.8s

  - Option A
    271s (3.66x)

Load S4P files	P1 FOM 12mm	P1 COM 12mm	Load S4P files	P2 FOM 12mm	P2 COM 12mm	Load S4P files	P1 FOM 30mm	P1 COM 30mm	Load S4P files	P2 FOM 30mm	P2 COM 30mm
38.5s	17.5s	6.4s	38.5s	29.1s	6.5s	38.5s	17.4s	6.8s	38.5s	26.7s	6.8s

  - Option B
    236s (4.22x)

Load S4P files	P1 FOM 12mm	P1 COM 12mm	Load S4P files	P2 FOM 12mm	P2 COM 12mm	Load S4P files	P1 FOM 30mm	P1 COM 30mm	Load S4P files	P2 FOM 30mm	P2 COM 30mm
38.5s	17.6s	6.4s	38.5s	10.4s	6.5s	38.5s	17.4s	6.8s	38.5s	9.5s	6.8s

- Estimated execution time without overhead
  - Full grid
    462s (2.15x)

Load S4P files	FOM 12mm	COM 12mm	FOM 30mm	COM 30mm
38.5s	198.1s	6.5s	212.4s	6.8s

  - Option A
    143s (6.97x)

Load S4P files	P1 FOM 12mm	P2 FOM 12mm	COM 12mm	P1 FOM 30mm	P2 FOM 30mm	COM 30mm
38.5s	17.5s	29.1s	6.5s	17.4s	26.7s	6.8s

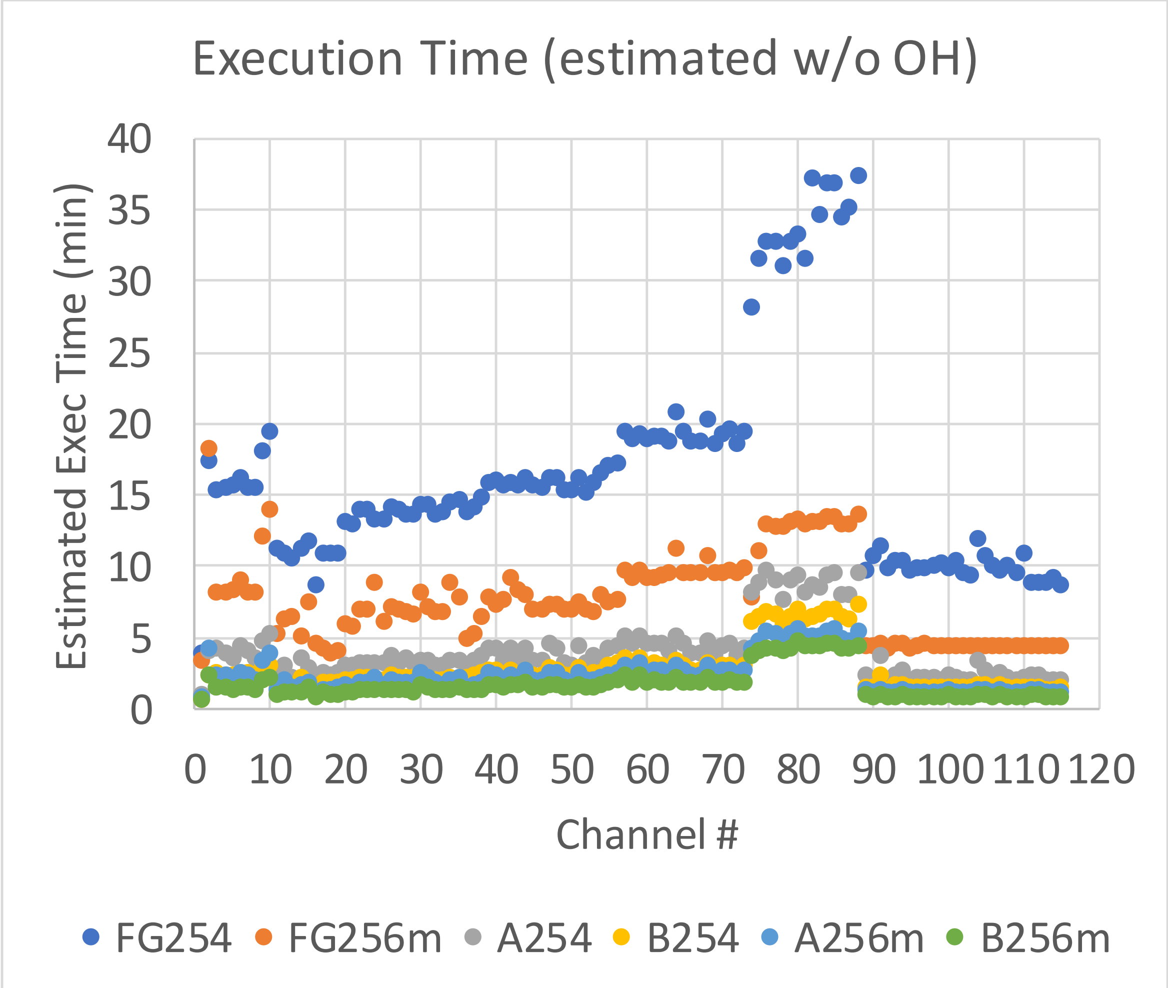
  - Option B
    107s (9.32x)

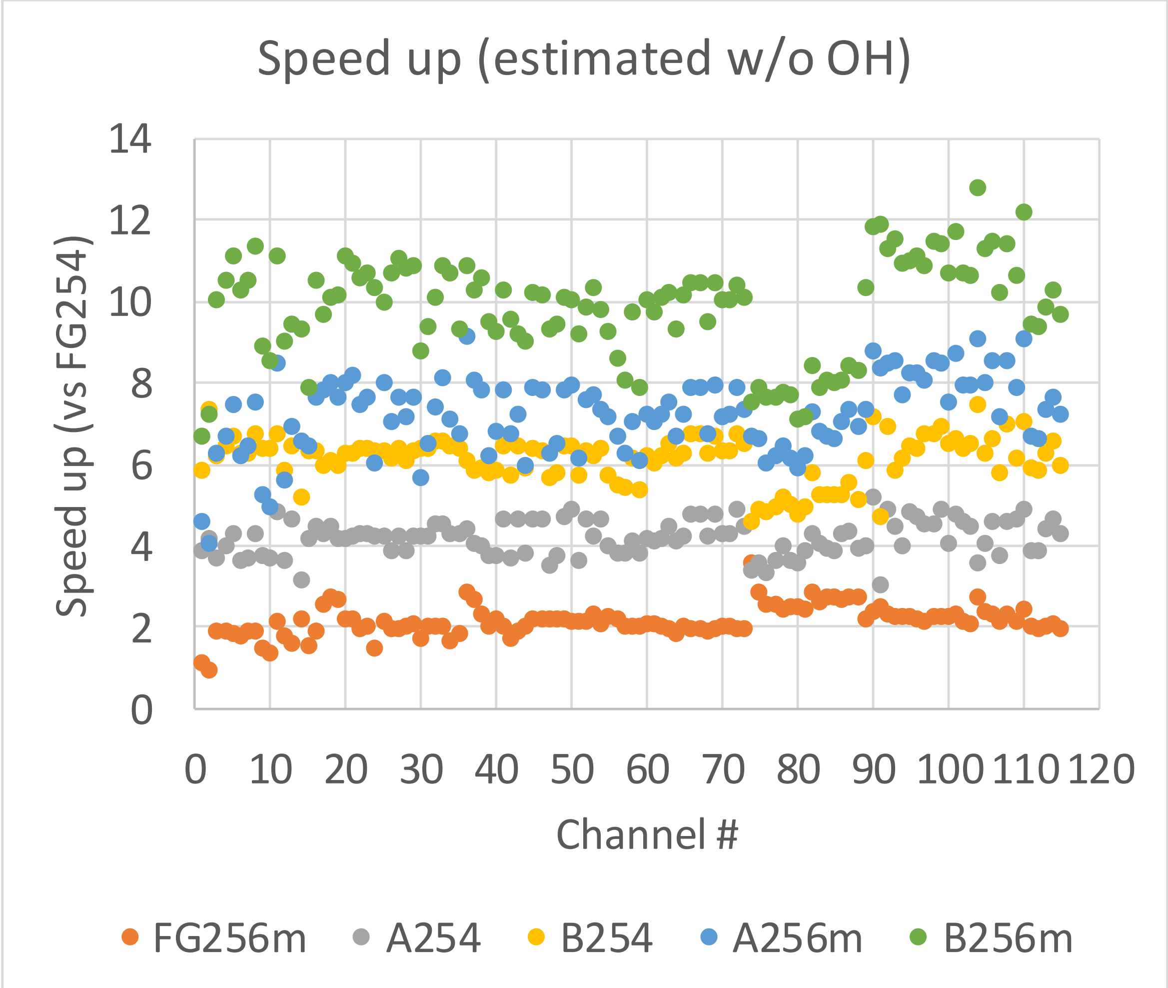
Load S4P files	P1 FOM 12mm	P2 FOM 12mm	COM 12mm	P1 FOM 30mm	P2 FOM 30mm	COM 30mm
38.5s	17.6s	10.4s	6.5s	17.4s	9.5s	6.8s

Estimated Exec Time without Overhead

- ➢ Average speed up will be 4.10x (option A) or 5.90x (option B) for v2.54
  - Or 6.97x (option A) or 9.32x (option B) when combined with Rich's speed up

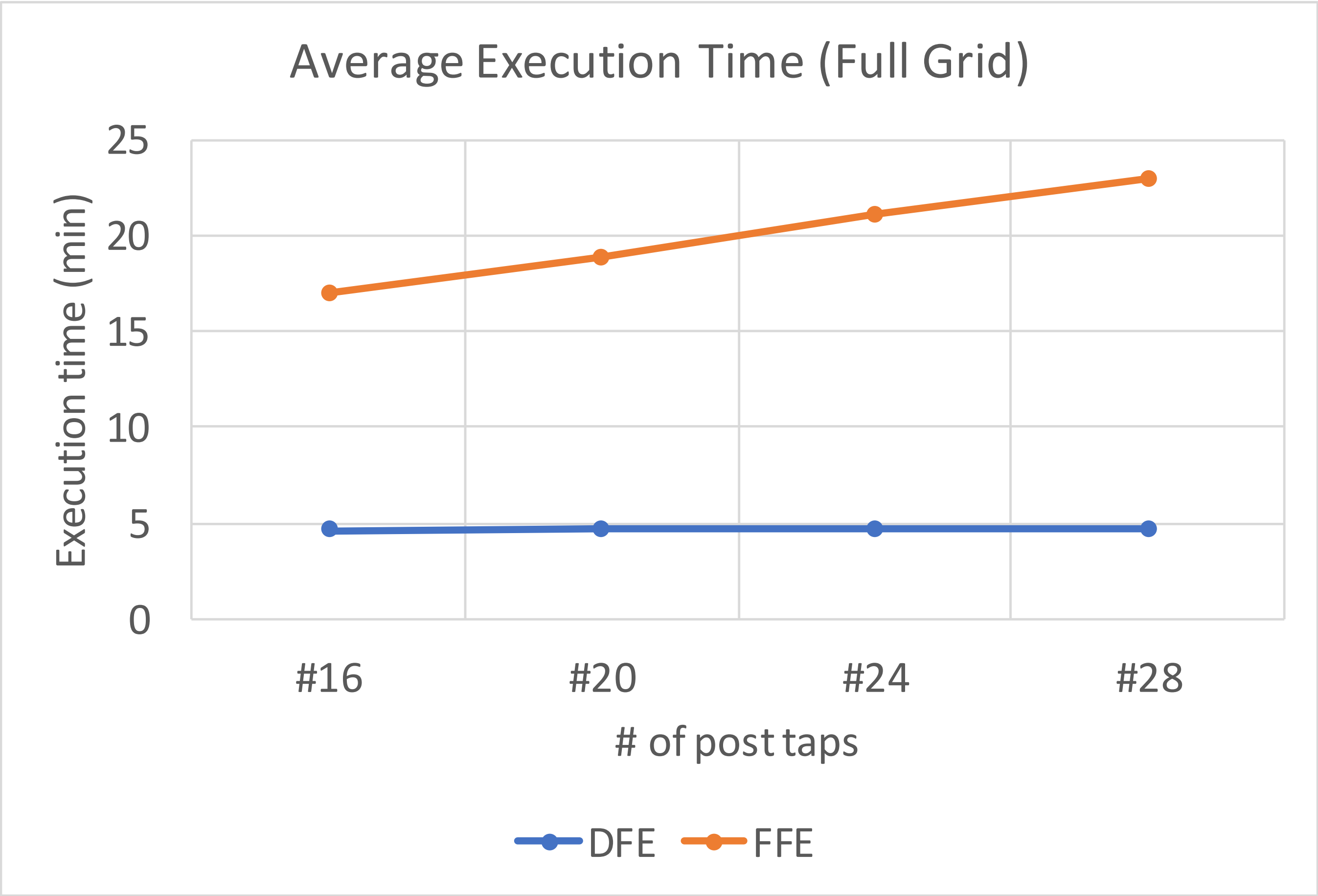
	Estimated Execution Time without Overhead (min)						Speed up (vs FG254)				
							by RM	by Two phase		Combined	
	FG254	FG256	A254	B254	A256m	B256m	FG256	A254	B254	A256m	B256m
max	37.47	18.22	9.80	7.29	5.65	4.69	3.59x	5.21x	7.49x	9.11x	12.82x
min	3.88	3.38	1.00	0.66	0.85	0.58	0.95x	3.01x	4.57x	4.04x	6.70x
average	16.56	7.70	4.04	2.81	2.38	1.78	**2.15x**	**4.10x**	**5.90x**	**6.97x**	**9.32x**

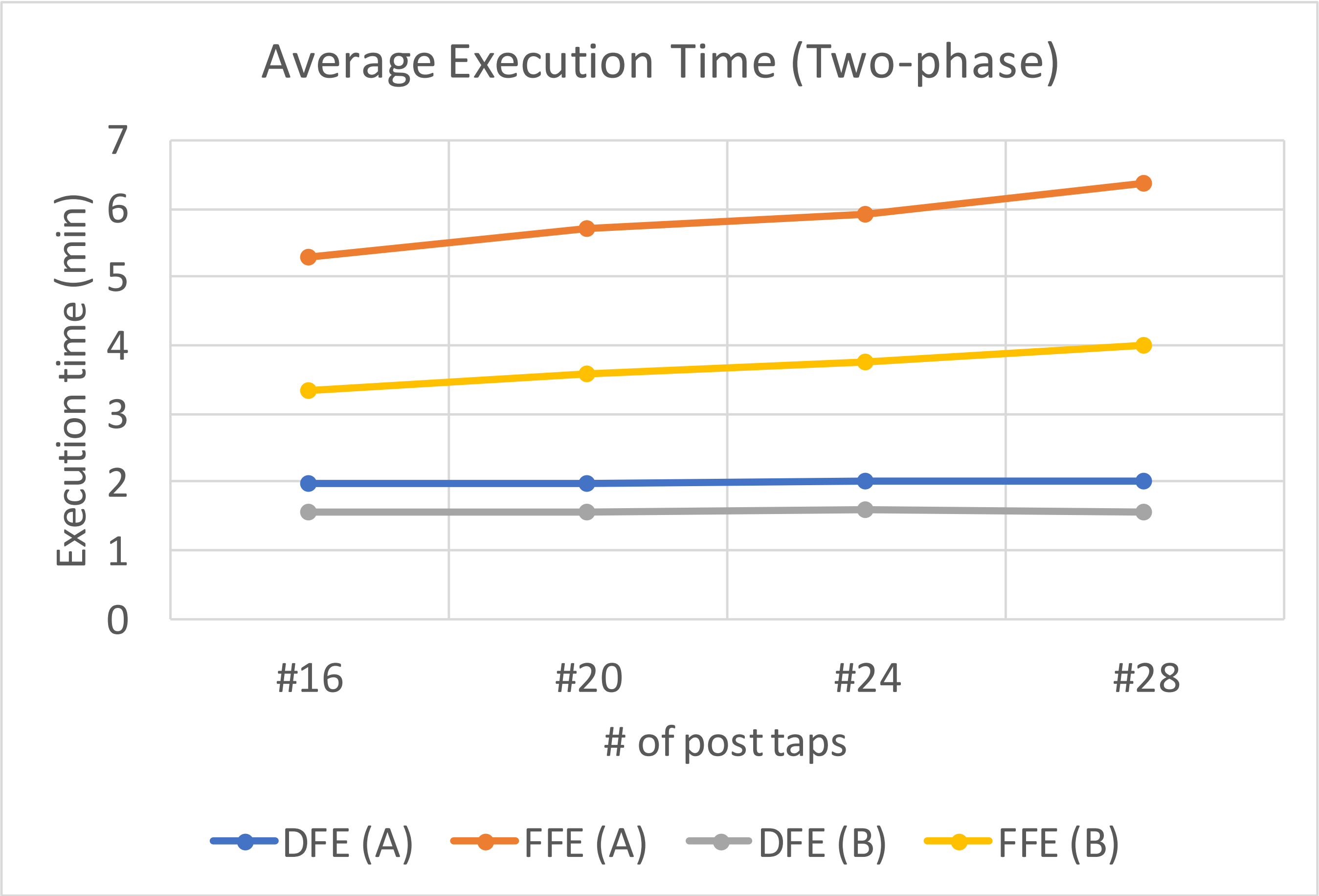




Execution Time by RX Model

- DFE-based model is much faster than FFE-based
  - FFE-based execution time increases with # of taps
  - DFE-based model is 4.4x faster than FFE-based with 24 post taps
- Both DFE- and FFE-based models will achieve speed up





#n: n-tap DFE or 3-pre/n-post FFE

This is average exec time for CH3, CH76, CH89
with one case of package trace lengths
using COM tool v2.56mod

This is estimated exec time without overhead.

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Summary

- Two-phase search will speed up COM tool by 4.10x ~ 5.90x
  - Option A
    - 100% same results as conventional full-grid search
    - 4.10x speed up by two-phase search
    - 6.97x speed up combined with RM's speed up
  - Option B
    - 95% same results as conventional full-grid search
      - COM may go up or down, because EQs are optimized by FOM
    - 5.90x speed up by two-phase search
    - 9.32x speed up combined with RM's speed up

- Small variation of COM has been existing due to FOM-based optimization
  - Two-phase search does not introduce extra variation for all channels simulated

- DFE-based model is observed to be much faster than FFE-based model

Back up

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

COM parameters (DFE16)

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	[1 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)	0.54		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(-4)	[0]		[min:step:max]
c(1)	[-0.1:0.05:0]		[min:step:max]
N_b	16	UI	
b_max(1)	0.85		
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	0	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	
Include PCB	0	Value
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	33	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

Algorithm Option A (min 5 grids)

- Phase 1

```
step = org_step;      max = org_max;    min = org_min;
nseg = round( (org_max – org_min) / org_step );
if (nseg > 4)
  step = org_step * 2;           % double the step size
end
```

- Phase 2

```
step = org_step;      max = org_max;    min = org_min;
nseg = round( (org_max – org_min) / org_step );
if (nseg > 4)
  qnseg = ceil( nseg / 4 );      % round up to the same or upper integer
  min = max(org_min, phase1_result – org_step * qnseg);
  max = min(org_max, phase1_result + org_step * qnseg);
end
```

Algorithm Option B (min 3 grids)

- Phase 1

```
step = org_step;      max = org_max;    min = org_min;
nseg = round( (org_max – org_min) / org_step );
if (nseg > 4)
  step = org_step * 2;            % double the step size
end
```

- Phase 2

```
step = org_step;      max = org_max;    min = org_min;
nseg = round( (org_max – org_min) / org_step );
if (nseg > 4)
  qnseg = floor( nseg / 4 );      % round down to the same or lower integer
  min = max(org_min, phase1_result – org_step * qnseg);
  max = min(org_max, phase1_result + org_step * qnseg);
end
```

Difference between Full-grid Search and Option B

PKG zp	CH #	Total IL	Fitted IL	ICN mV	TX FIR		gDC		gDC2		FOM			COM		
					Full Grid	Option B	FG	OB	FG	OB	Full Grid	Opt. B	OB - FG	Full Grid	Opt. B	OB - FG
12	6	29.19	22.98	0.88	[-0.02 0.08 -0.24 0.66 0]	[0 0.04 -0.2 0.76 0]	-10	-10	-3	-3	16.7815	16.7263	-0.0552	6.3031	6.1431	-0.1600
	28	32.02	25.11	1.60	[-0.02 0.08 -0.26 0.64 0]	[0 0.04 -0.22 0.74 0]	-11	-12	-2	-2	15.1575	14.9940	**-0.1635**	4.7614	4.4805	-0.2809
	39	29.82	20.95	1.77	[-0.02 0.08 -0.26 0.64 0]	[0 0.04 -0.22 0.74 0]	-7	-8	-2	-2	12.9105	12.8301	-0.0804	2.9139	2.5452	-0.3687
	44	34.64	25.54	1.77	[0 0.04 -0.22 0.74 0]	[-0.02 0.08 -0.26 0.64 0]	-11	-10	-3	-3	11.9066	11.7440	-0.1626	2.1359	2.4066	**0.2707**
	54	45.31	35.09	1.77	[0 0.04 -0.24 0.72 0]	[0 0.02 -0.22 0.76 0]	-17	-17	-4	-4	7.8329	7.7267	-0.1062	-0.82785	-1.3414	**-0.51355**
30	1	35.14	28.01	0.00	[-0.02 0.08 -0.24 0.66 0]	[0 0.04 -0.2 0.71 -0.05]	-19	-19	-2	-2	15.1463	15.1367	-0.0096	3.9172	3.9172	0.0000
	13	37.73	30.34	2.65	[0 0.04 -0.28 0.68 0]	[0 0.02 -0.26 0.72 0]	-16	-18	-3	-3	8.2306	8.2003	-0.0303	-1.4008	-1.4817	-0.0809
	26	23.83	17.82	2.26	[-0.02 0.08 -0.24 0.61 -0.05]	[0 0.04 -0.22 0.74 0]	-8	-10	-2	-2	14.842	14.7685	-0.0735	4.1102	3.8900	-0.2202
	33	36.35	29.42	1.55	[-0.02 0.08 -0.26 0.64 0]	[-0.02 0.08 -0.26 0.64 0]	-17	-17	-4	-3	11.8882	11.8771	-0.0111	1.1499	1.1202	-0.0297
	48	36.97	27.52	1.77	[0 0.04 -0.24 0.72 0]	[0 0.06 -0.26 0.68 0]	-15	-15	-4	-3	11.0199	10.9512	-0.0687	1.4218	1.5975	0.1757
	76	30.98	24.34	1.12	[-0.02 0.08 -0.26 0.64 0]	[0 0.04 -0.22 0.74 0]	-13	-14	-4	-4	12.7397	12.5900	-0.1497	2.1359	1.8518	-0.2841

Better results of Phase 1 than Full-Grid Search

PKG zp	CH #	Total IL	Fitted IL	ICN mV	TX FIR		gDC		gDC2		FOM			COM		
					Full Grid	Phase 1	FG	P1	FG	P1	Full Grid	Phase 1	P1 – FG	Full Grid	Phase 1	P1 – FG
12	10	33.61	27.84	1.91	*[0 0.02 -0.2 0.78 0]*	*[0 0.04 -0.22 0.74 0]*	*-13*	*-14*	*-3*	*-4*	11.4581	11.3270	-0.1311	1.7556	1.8196	0.0640
	17	38.31	29.74	2.05	*[0 0.06 -0.26 0.68 0]*	*[-0.02 0.08 -0.26 0.64 0]*	-14	-14	-2	-2	10.8454	10.6599	-0.1855	1.5144	1.5975	0.0831
	18	37.57	29.62	2.03	*[0 0.06 -0.26 0.68 0]*	*[-0.02 0.08 -0.26 0.64 0]*	-14	-14	-2	-2	10.8957	10.6698	-0.2259	1.6184	1.6815	0.0631
	44	34.64	25.54	1.77	*[0 0.04 -0.22 0.74 0]*	*[-0.02 0.08 -0.26 0.64 0]*	*-11*	*-10*	*-3*	*-2*	11.9066	11.6283	-0.2783	2.1359	2.1804	0.0445
	46	36.12	27.09	1.77	*[0 0.06 -0.30.64 0]*	*[-0.02 0.08 -0.3 0.6 0]*	*-9*	*-10*	*-3*	*-2*	10.1452	9.9526	-0.1926	0.50056	0.54669	0.04613
	88	40.48	33.04	0.69	*[0 0.06 -0.26 0.68 0]*	*[-0.02 0.08 -0.26 0.64 0]*	*-15*	*-16*	-4	-4	11.3821	11.2469	-0.1352	0.91515	0.92481	0.00966
30	48	42.16	27.52	1.77	*[0 0.04 -0.24 0.72 0]*	*[-0.02 0.08 -0.26 0.64 0]*	*-15*	*-14*	-4	-4	11.0199	10.8494	-0.1705	1.4218	1.7237	0.3019