TX FIR Equalizer

12 Gbps

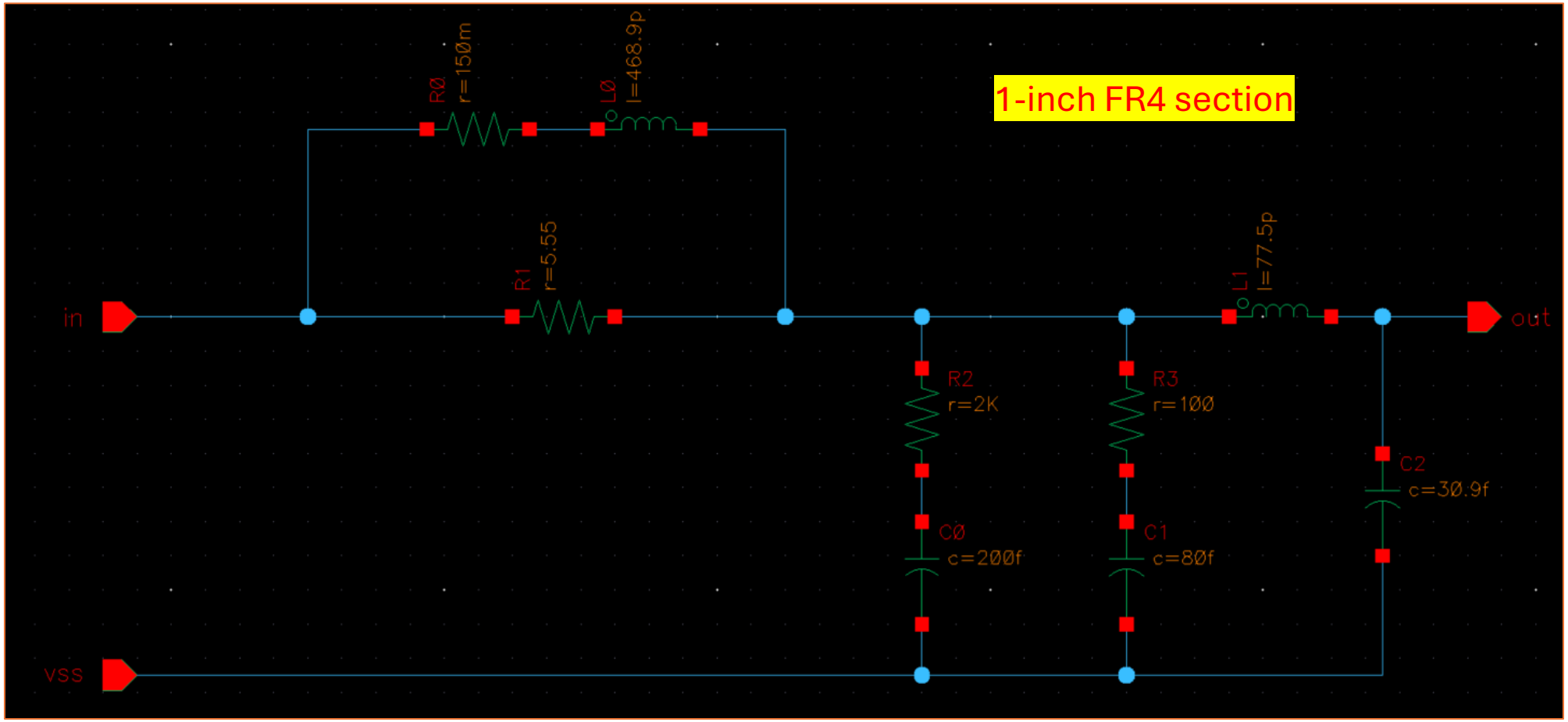
(Pulse Response)

Muhammad Aldacher

Design Parameters

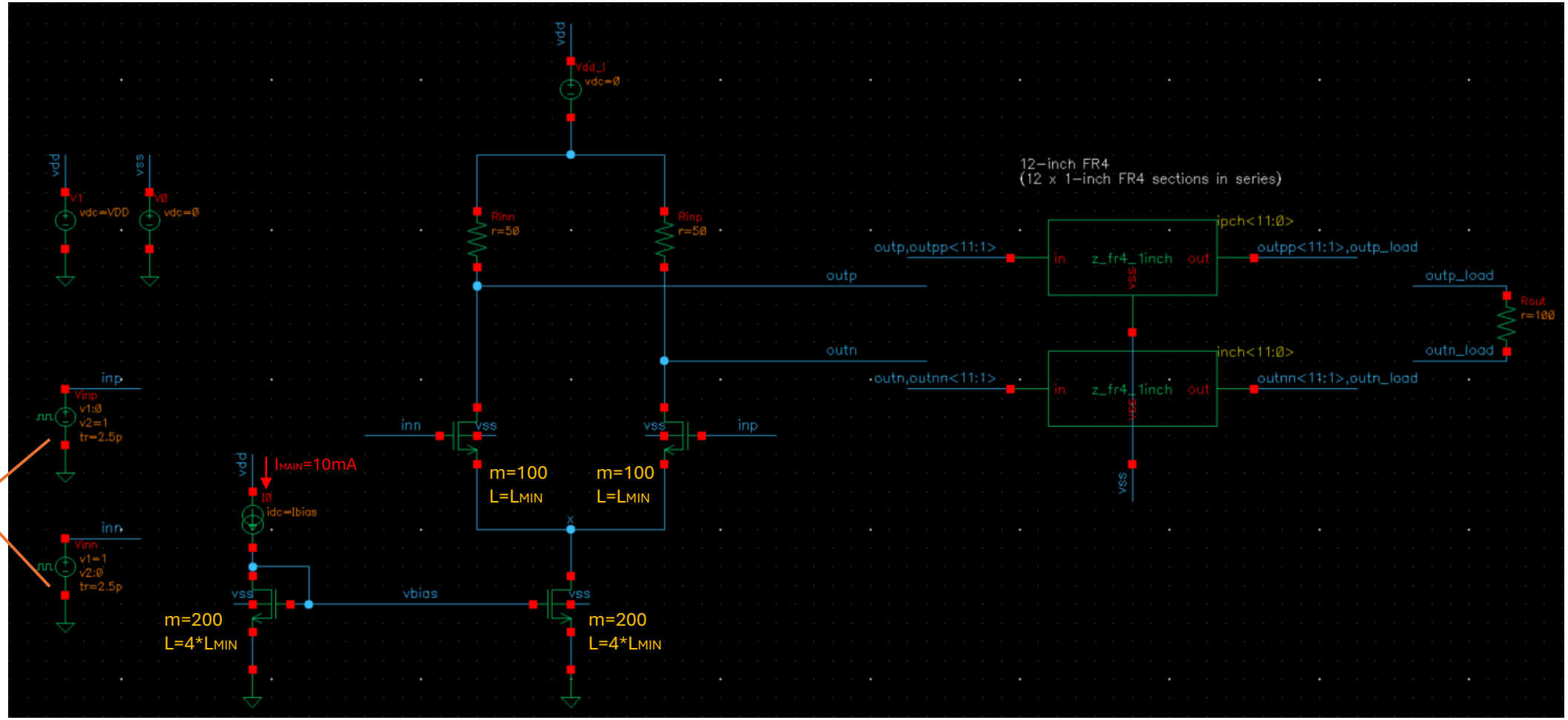
Parameter	Value
Data Rate	12 Gb/s
VDD	1 V
Tx-Driver	Current Mode (CML)
$V_{SWING\ (PK2PK)}$	0.5 V
I_{BIAS}	10mA
Channel	12-inch FR4

Channel = 12 x 1-inch FR4 section



1) Pulse Response (without Equalization)

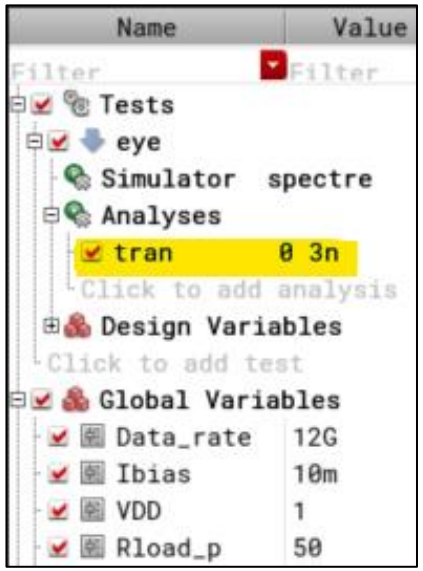
TB Schematics



LIB: **analogLib**
CELL: **vpulse**

Voltage1: **0 V** / 1 V
Voltage2: **1 V** / 0 V
Period: **10u**
Delay time: **1 ns**
Rise/Fall times: **2.5 ps**
Pulse width: **83.33ps (1/12G)**

Analysis Setup

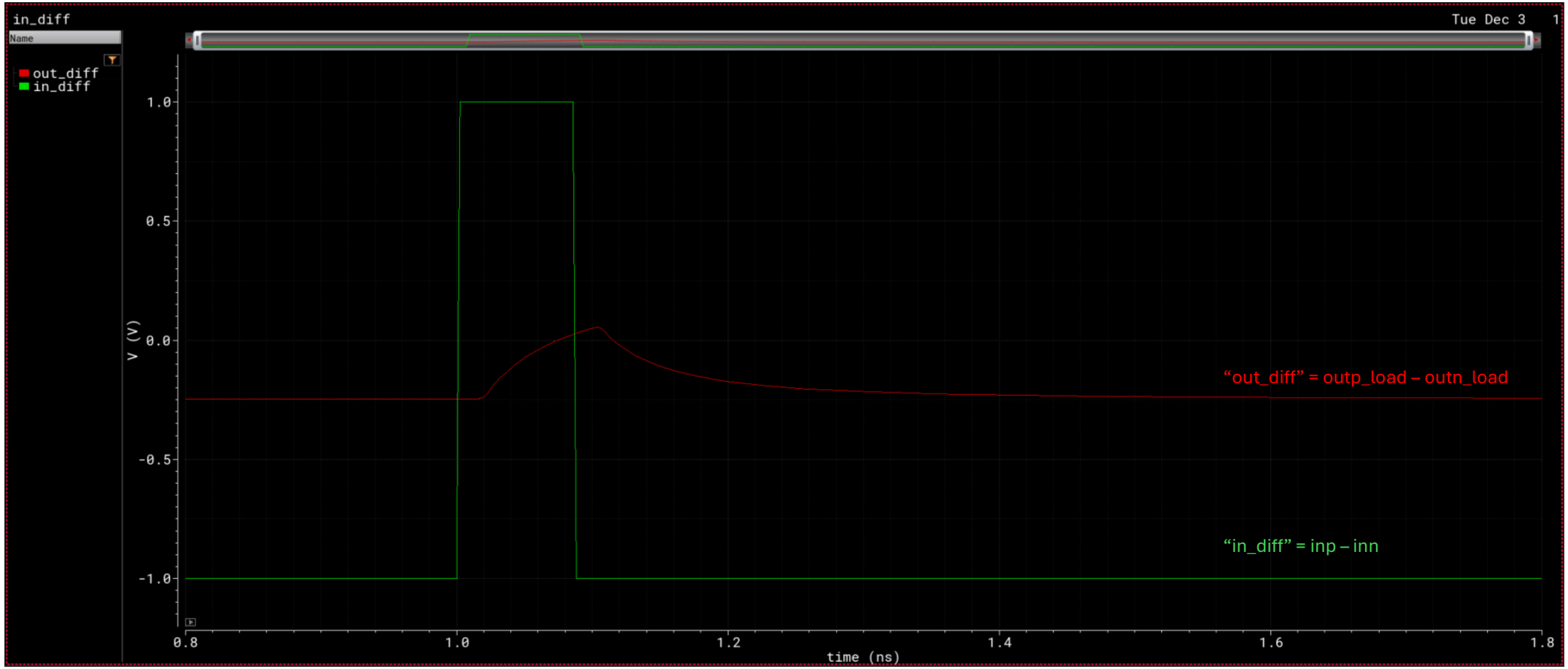


Name	Type	Details	EvalType
Filter	Filter	Filter	Filter
	signal	/x	point
	signal	/vbias	point
	signal	/outp	point
	signal	/outn	point
	signal	/outp_load	point
	signal	/outn_load	point
in_diff	expr	(VT("/inp") - VT("/inn"))	point
out_diff	expr	(VT("/outp_load") - VT("/outn_load"))	point
out_diff_shifted	expr	(out_diff + (0.5 * VAR("Ibias") * VAR("Rload_p")))	point
** Expressions **	expr		point
Data_rate	expr	VAR("Data_rate")	point
UI	expr	(1 / Data_rate)	point
** Main Cursor **	expr		point
t_cursor_main	expr	xmax(out_diff_shifted)	point
cursor_main	expr	value(out_diff_shifted t_cursor_main)	point
** Post & Pre Cursors **	expr		point
t_cursor_pre_2	expr	(t_cursor_main - (2 * UI))	point
t_cursor_pre_1	expr	(t_cursor_main - UI)	point
t_cursor_post_1	expr	(t_cursor_main + UI)	point
t_cursor_post_2	expr	(t_cursor_main + (2 * UI))	point
t_cursor_post_3	expr	(t_cursor_main + (3 * UI))	point
t_cursor_post_4	expr	(t_cursor_main + (4 * UI))	point
t_cursor_post_5	expr	(t_cursor_main + (5 * UI))	point
cursor_pre_2	expr	value(out_diff_shifted t_cursor_pre_2)	point
cursor_pre_1	expr	value(out_diff_shifted t_cursor_pre_1)	point
cursor_post_1	expr	value(out_diff_shifted t_cursor_post_1)	point
cursor_post_2	expr	value(out_diff_shifted t_cursor_post_2)	point
cursor_post_3	expr	value(out_diff_shifted t_cursor_post_3)	point
cursor_post_4	expr	value(out_diff_shifted t_cursor_post_4)	point
cursor_post_5	expr	value(out_diff_shifted t_cursor_post_5)	point

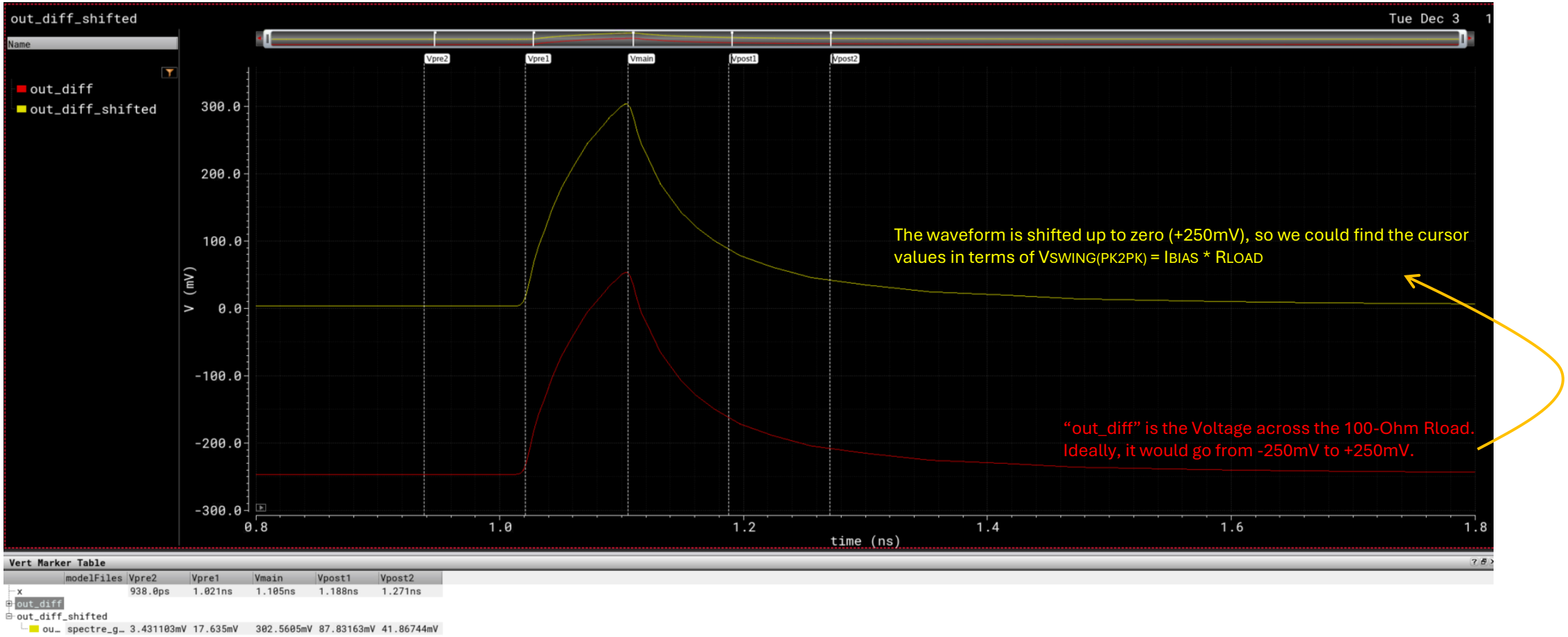
Results

Output	TT	Pass/Fail
Filter	Filter	Filter
/x		
/vbias		
/outp		
/outn		
/outp_load		
/outn_load		
in_diff		
out_diff		
out_diff_shifted		
** Expressions **		
Data_rate	12G	
UI	83.33p	
** Main Cursor **		
t_cursor_main	1.105n	
cursor_main	303.3m	
** Post & Pre Cursors **		
t_cursor_pre_2	938p	
t_cursor_pre_1	1.021n	
t_cursor_post_1	1.188n	
t_cursor_post_2	1.271n	
t_cursor_post_3	1.355n	
t_cursor_post_4	1.438n	
t_cursor_post_5	1.521n	
cursor_pre_2	3.431m	
cursor_pre_1	19.12m	
cursor_post_1	87.82m	
cursor_post_2	41.78m	
cursor_post_3	24.34m	
cursor_post_4	17.41m	
cursor_post_5	12.43m	

Waveforms

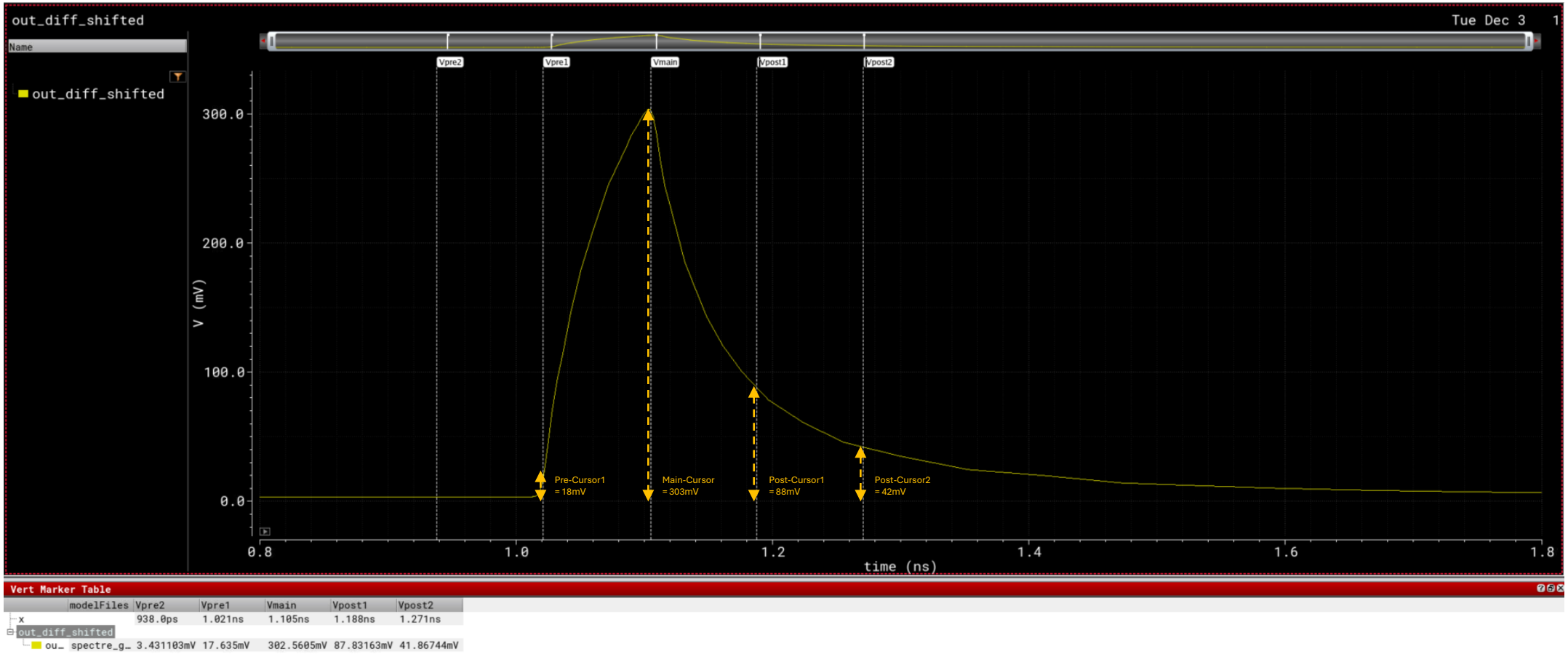

in_diff
Tue Dec 3
Name
out_diff
in_diff
1.0
0.5
0.0
-0.5
-1.0
V (V)
0.8
1.0
1.2
1.4
1.6
1.8
time (ns)
“out_diff” = outp_load – outn_load
“in_diff” = inp – inn

Waveforms


out_diff_shifted
Tue Dec 3
Name
out_diff
out_diff_shifted
Vpre2
Vpre1
Vmain
Vpost1
Vpost2
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
V (mV)
0.8
1.0
1.2
1.4
1.6
1.8
time (ns)
The waveform is shifted up to zero (+250mV), so we could find the cursor values in terms of VSWING(PK2PK) = IBIAS * RLOAD
"out_diff" is the Voltage across the 100-Ohm Rload. Ideally, it would go from -250mV to +250mV.
Vert Marker Table
modelFiles Vpre2 Vpre1 Vmain Vpost1 Vpost2
x 938.0ps 1.021ns 1.105ns 1.188ns 1.271ns
out_diff
out_diff_shifted
ou… spectre_g… 3.431103mV 17.635mV 302.5605mV 87.83163mV 41.86744mV

Waveforms

	Pre-Cursor1	Main-Cursor	Post-Cursor1	Post-Cursor2
Adjusted $V_{SWING(PK2PK)}$	(18 / 303) * 500 mV = **29.7 mV**	(303 / 303) * 500 mV = **500 mV**	(88 / 303) * 500 mV = **145.2 mV**	(42 / 303) * 500 mV = **69.3 mV**
Equivalent I_{BIAS}	29.7 mV / 50 Ohms = **0.6 mA**	500 mV / 50 Ohms = **10 mA**	145.2 mV / 50 Ohms = **2.9 mA**	69.3 mV / 50 Ohms = **1.4 mA**
# of fingers	**(m = 12)**	**(m = 200)**	**(m = 58)**	**(m = 28)**



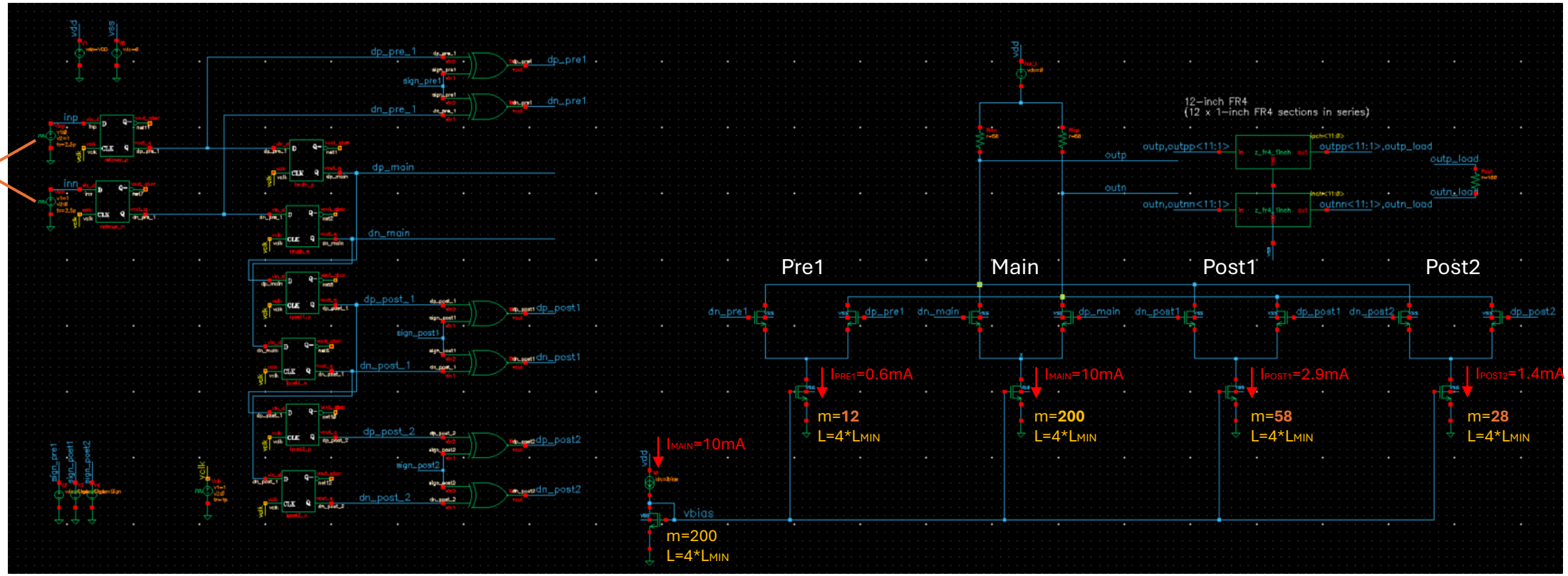
2) Pulse Response (with Equalization)

TB Schematics

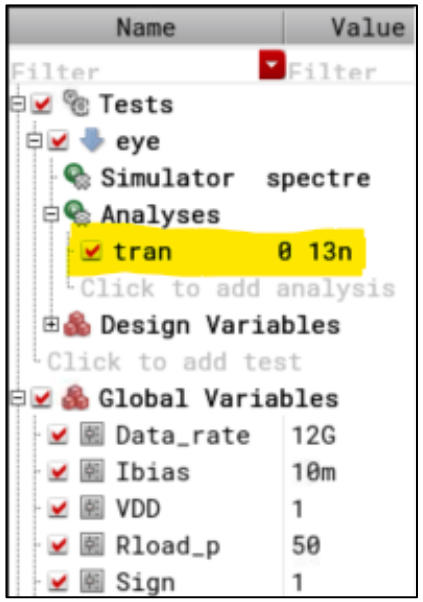
LIB: **analogLib**
CELL: **vpulse**

Voltage1: **0 V** / 1 V
Voltage2: **1 V** / 0 V
Period: **10u**
Delay time: **11 ns**
Rise/Fall times: **2.5 ps**
Pulse width: **83.33ps (1/12G)**

* Delay time is increased to make sure that we start the pulse response measurements with steady-state levels.



Analysis Setup



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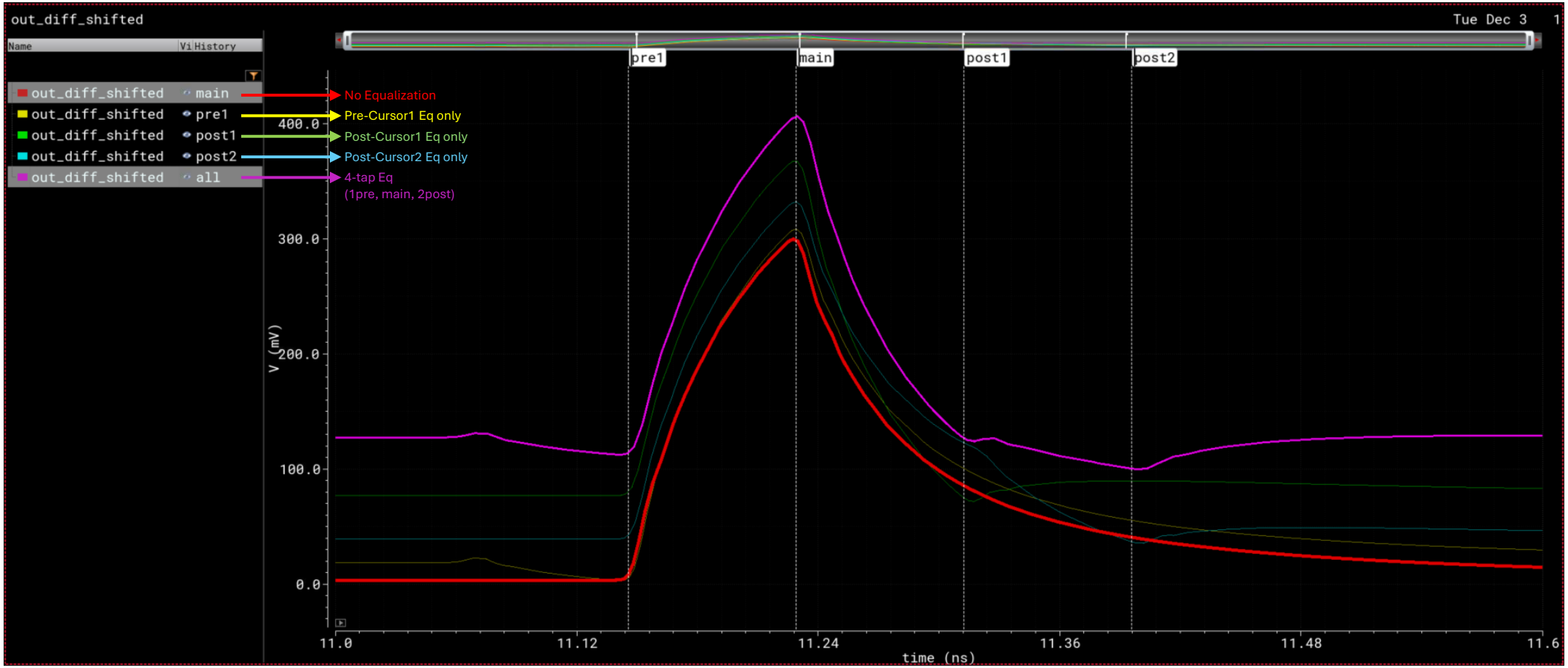
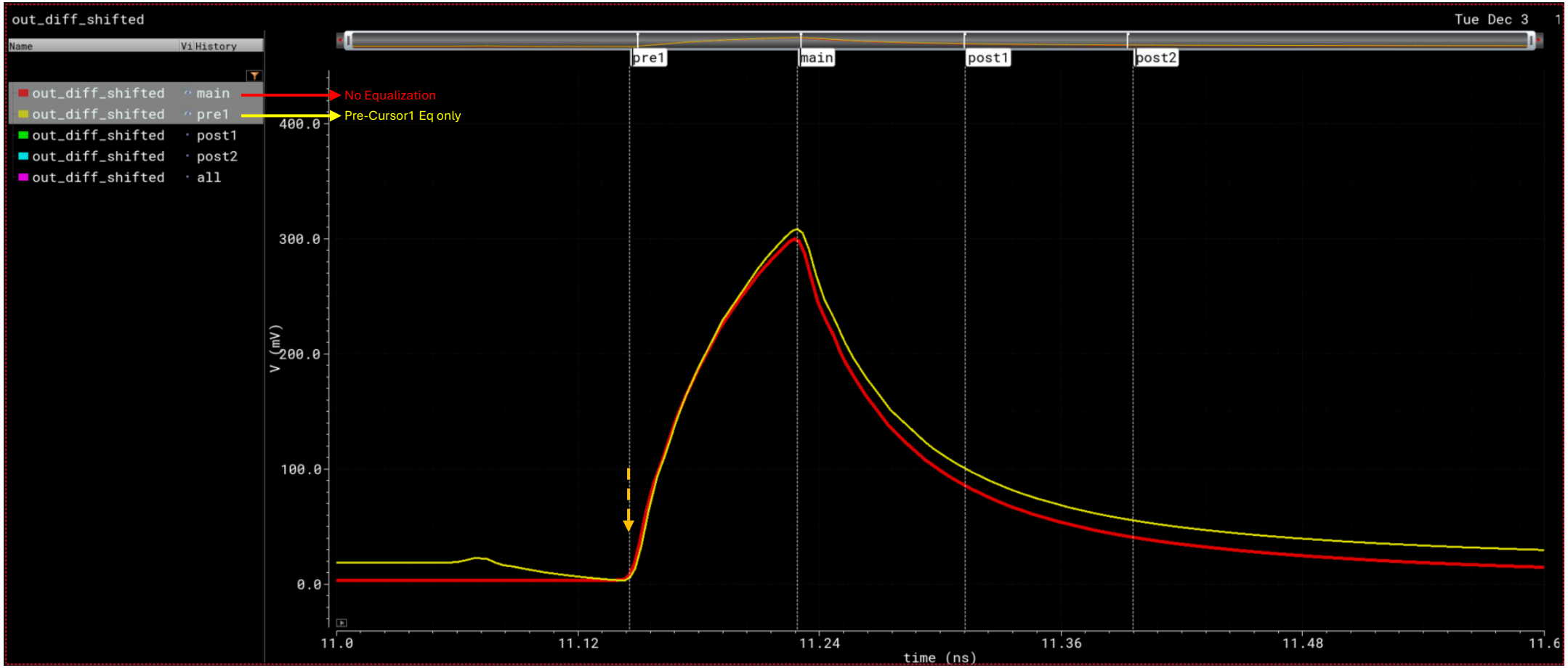
Filter	Filter	Filter	Filter
	signal	/x	point
	signal	/vbias	point
	signal	/outp	point
	signal	/outn	point
	signal	/outp_load	point
	signal	/outn_load	point
in_diff	expr	(VT("/inp") - VT("/inn"))	point
out_diff	expr	(VT("/outp_load") - VT("/outn_load"))	point
out_diff_shifted	expr	(out_diff + (0.5 * VAR("Ibias") * VAR("Rload_p")))	point
** Expressions **	expr		point
Data_rate	expr	VAR("Data_rate")	point
UI	expr	(1 / Data_rate)	point
** Main Cursor **	expr		point
t_cursor_main	expr	xmax(out_diff_shifted)	point
cursor_main	expr	value(out_diff_shifted t_cursor_main)	point
** Post & Pre Cursors **	expr		point
t_cursor_pre_2	expr	(t_cursor_main - (2 * UI))	point
t_cursor_pre_1	expr	(t_cursor_main - UI)	point
t_cursor_post_1	expr	(t_cursor_main + UI)	point
t_cursor_post_2	expr	(t_cursor_main + (2 * UI))	point
t_cursor_post_3	expr	(t_cursor_main + (3 * UI))	point
t_cursor_post_4	expr	(t_cursor_main + (4 * UI))	point
t_cursor_post_5	expr	(t_cursor_main + (5 * UI))	point
cursor_pre_2	expr	value(out_diff_shifted t_cursor_pre_2)	point
cursor_pre_1	expr	value(out_diff_shifted t_cursor_pre_1)	point
cursor_post_1	expr	value(out_diff_shifted t_cursor_post_1)	point
cursor_post_2	expr	value(out_diff_shifted t_cursor_post_2)	point
cursor_post_3	expr	value(out_diff_shifted t_cursor_post_3)	point
cursor_post_4	expr	value(out_diff_shifted t_cursor_post_4)	point
cursor_post_5	expr	value(out_diff_shifted t_cursor_post_5)	point

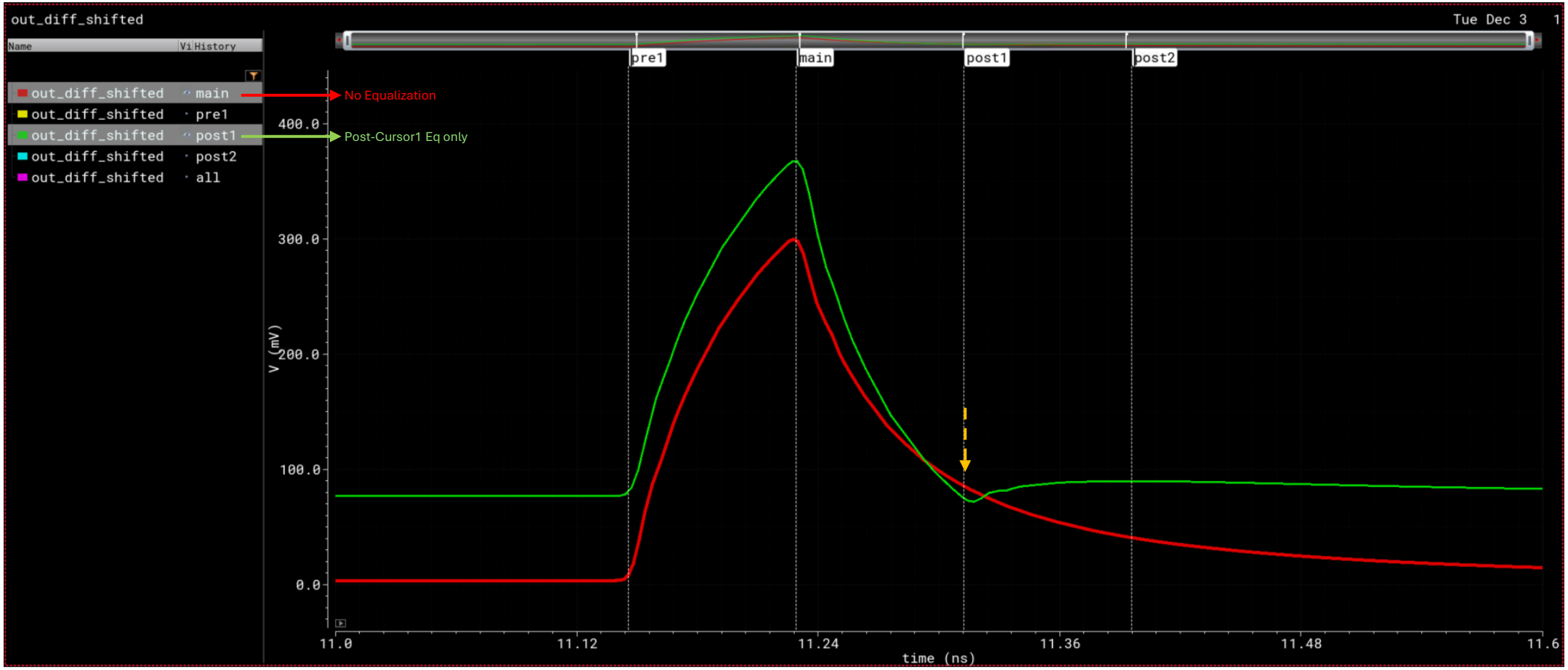
Waveforms


out_diff_shifted
Tue Dec 3
Name
Vi History
out_diff_shifted main
out_diff_shifted pre1
out_diff_shifted post1
out_diff_shifted post2
out_diff_shifted all
No Equalization
Pre-Cursor1 Eq only
Post-Cursor1 Eq only
Post-Cursor2 Eq only
4-tap Eq
(1pre, main, 2post)
pre1
main
post1
post2
400.0
300.0
200.0
100.0
0.0
V (mV)
11.0
11.12
11.24
11.36
11.48
11.6
time (ns)

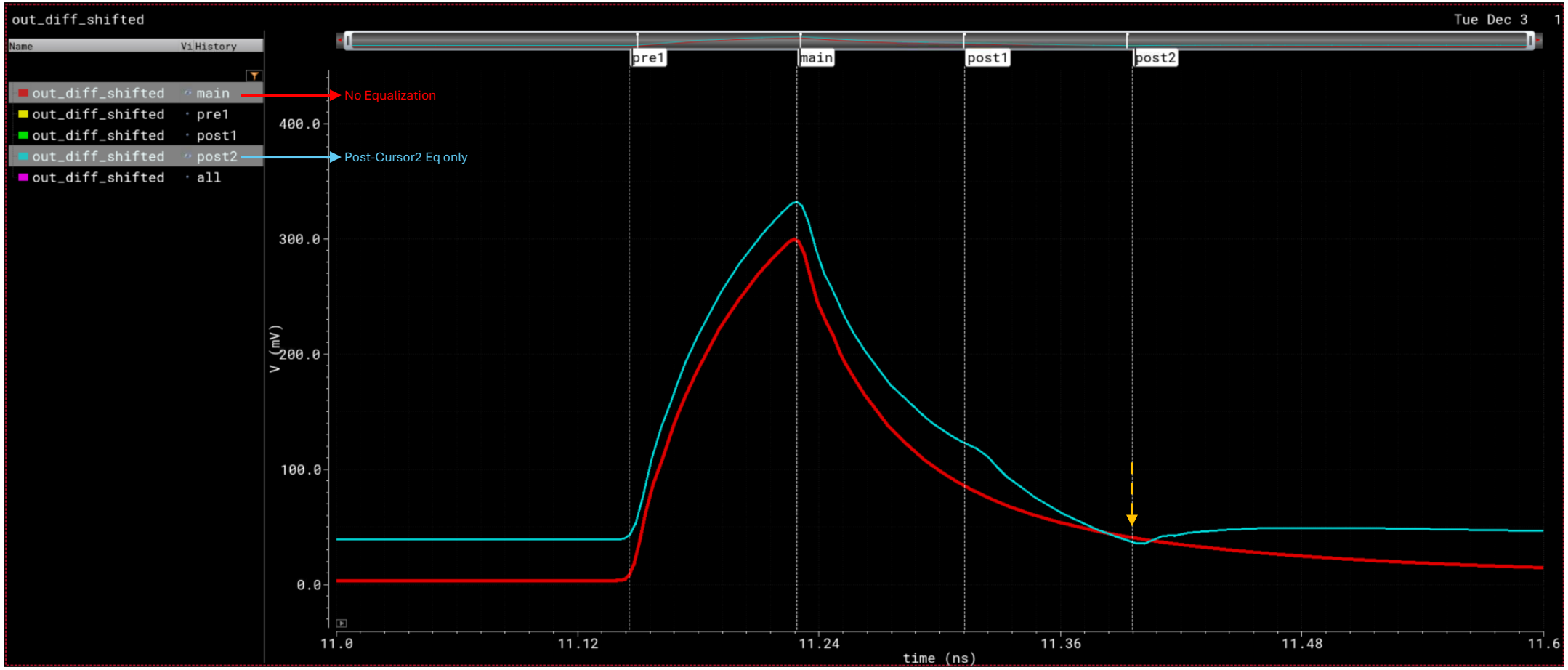
Waveforms


out_diff_shifted
Tue Dec 3
Name
Vi History
out_diff_shifted main
out_diff_shifted pre1
out_diff_shifted post1
out_diff_shifted post2
out_diff_shifted all
No Equalization
Pre-Cursor1 Eq only
pre1
main
post1
post2
400.0
300.0
200.0
100.0
0.0
V (mV)
11.0
11.12
11.24
11.36
11.48
11.6
time (ns)

Waveforms


out_diff_shifted
Tue Dec 3
Name
Vi History
out_diff_shifted main
out_diff_shifted pre1
out_diff_shifted post1
out_diff_shifted post2
out_diff_shifted all
No Equalization
Post-Cursor1 Eq only
pre1
main
post1
post2
400.0
300.0
200.0
100.0
0.0
V (mV)
11.0
11.12
11.24
11.36
11.48
11.6
time (ns)

Waveforms


out_diff_shifted
Tue Dec 3
Name
Vi History
out_diff_shifted main
out_diff_shifted pre1
out_diff_shifted post1
out_diff_shifted post2
out_diff_shifted all
No Equalization
Post-Cursor2 Eq only
pre1
main
post1
post2
400.0
300.0
200.0
100.0
0.0
V (mV)
11.0
11.12
11.24
11.36
11.48
11.6
time (ns)

Waveforms (with all taps)