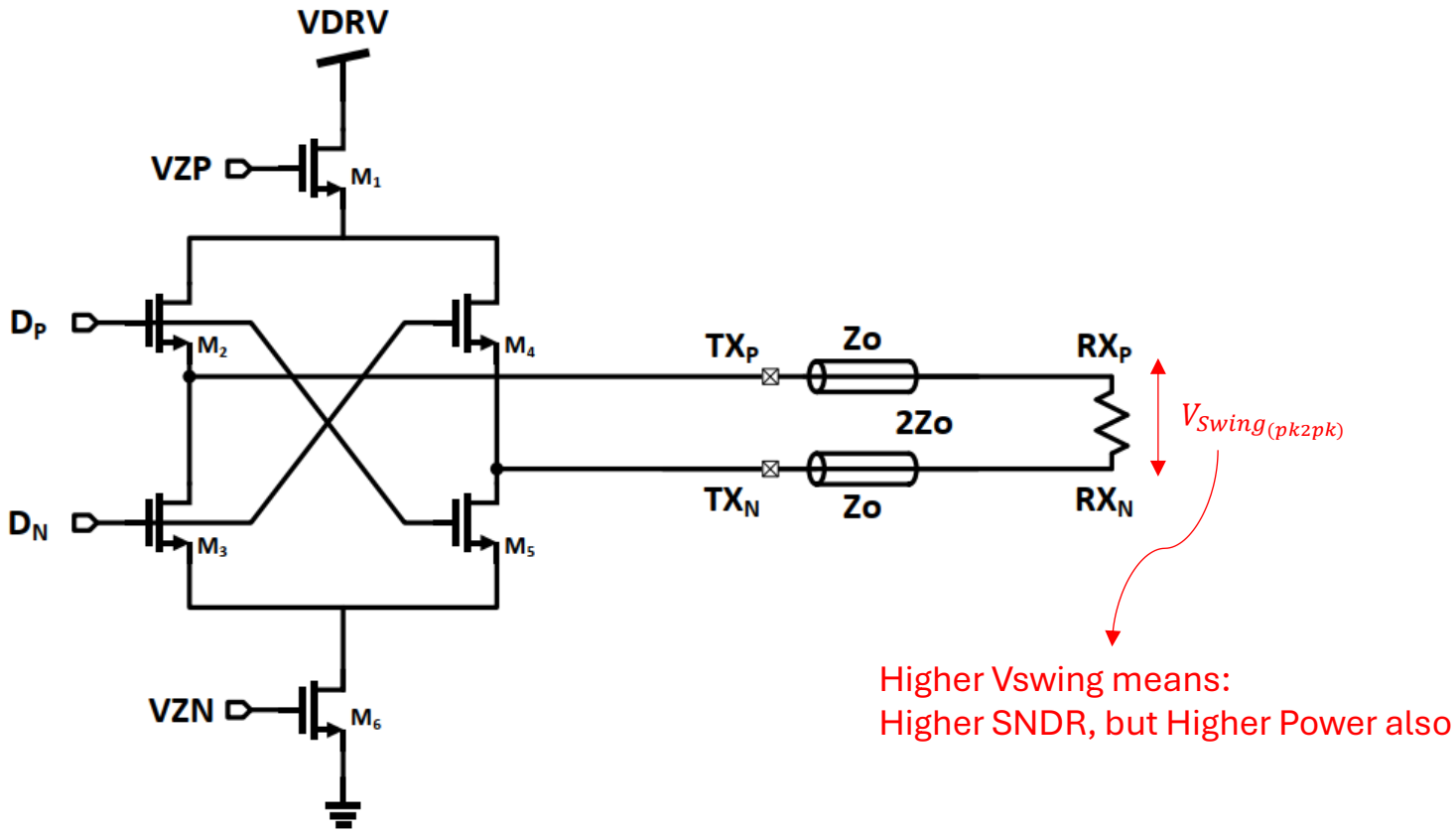
Tx Driver - VM

1 Gbps

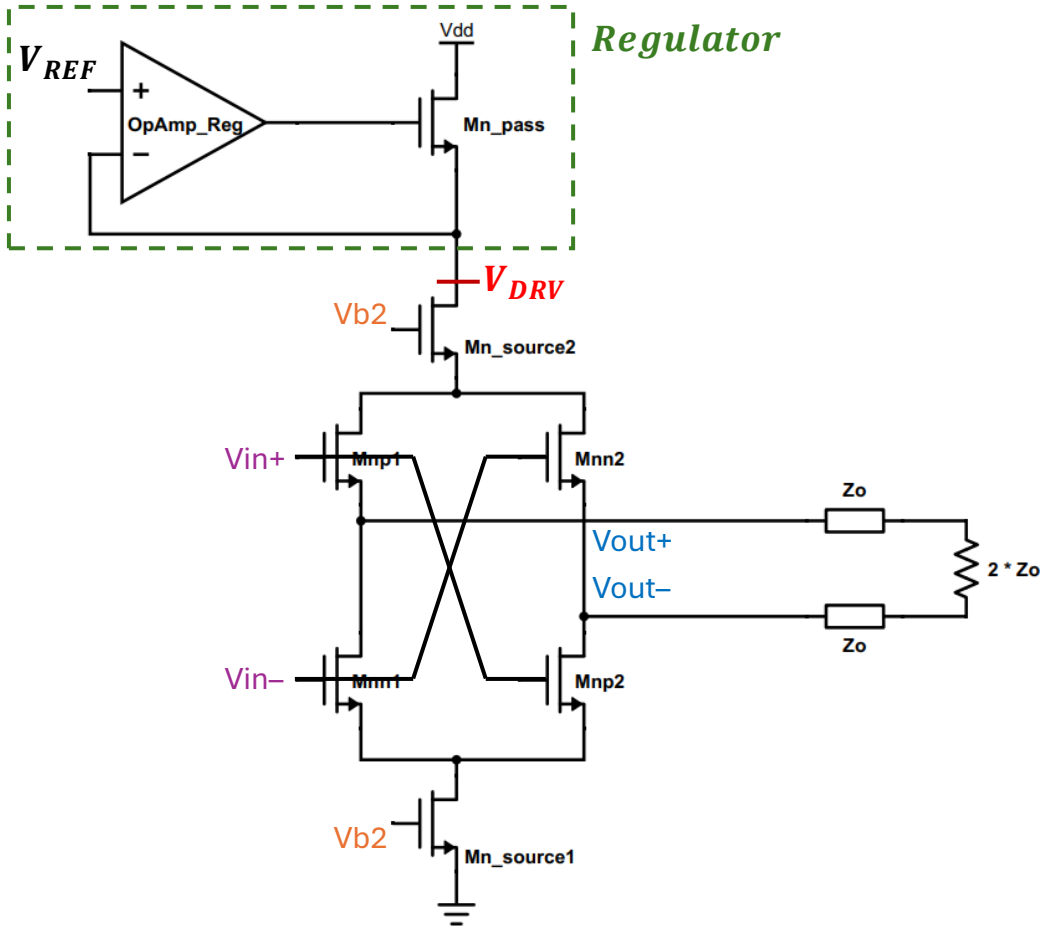
Muhammad Aldacher

Voltage-Mode Driver (VM)



1) Without Replica

$$V_{Swing_{(pk2pk)}} = V_{DRV} = V_{REF}$$



$$For\ V_{Swing_{(pk2pk)}} = 500\ mV:$$

$$V_{REF} = V_{DRV} = \mathbf{500\ mV}$$

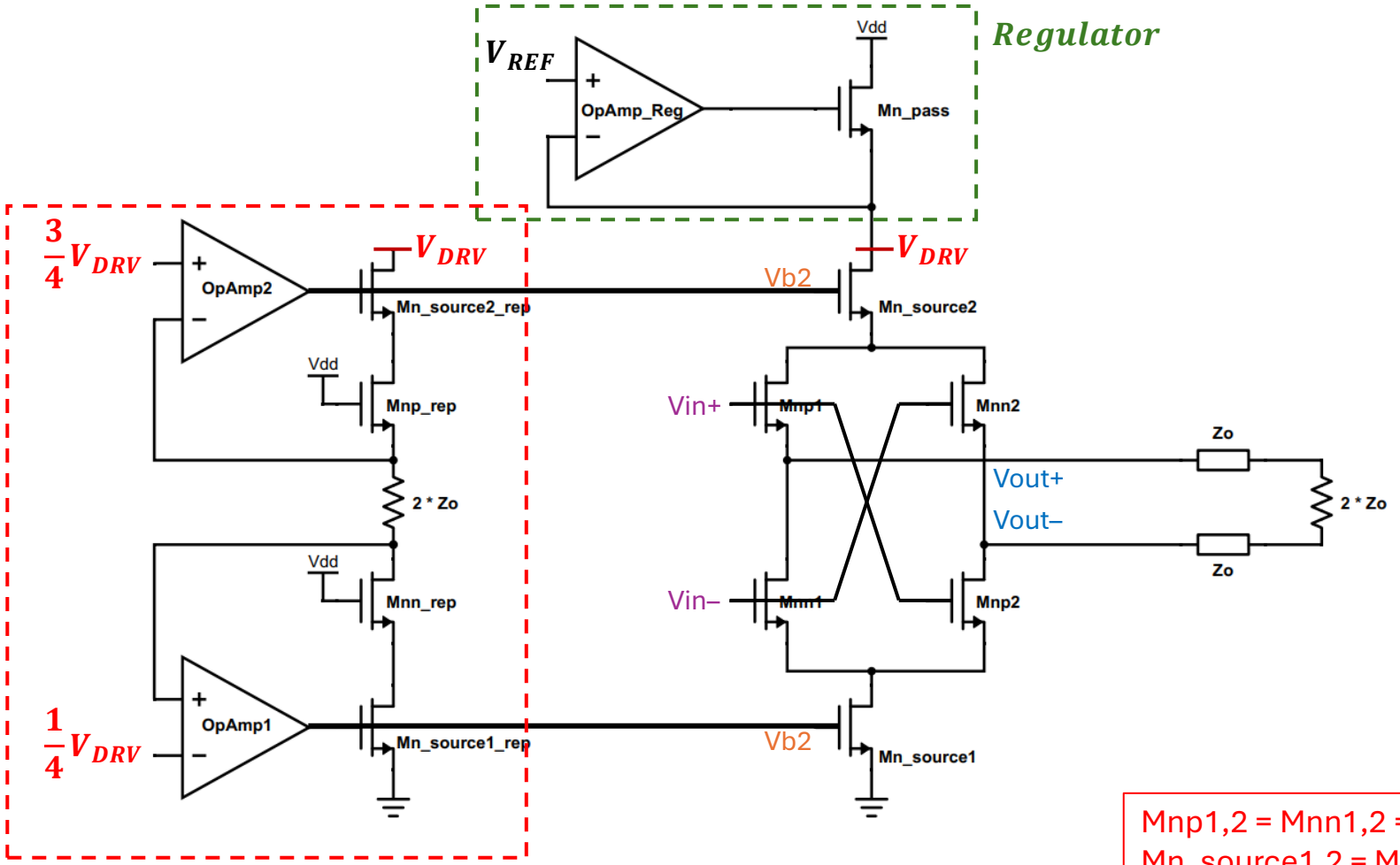
Device Sizing:

- Input devices (Mnp1,2 & Mnn1,2) act as switches, so we should increase W (reducing R_{ON}) to improve headroom.
- Bias devices (Mn_source1,2) should have their W & gate voltages Vb1,2 adjusted so that the output voltages would be at ¾ V_{DRV} & ¼ V_{DRV}.

Mnp1,2 = Mnn1,2 :	$L = L_{MIN}$	, m=100x
Mn_source1,2 :	$L = L_{MIN}$	, m=200x

2) With Replica

$$V_{Swing_{(pk2pk)}} = V_{DRV} = V_{REF}$$



- For the L of the Bias devices (Mn_source1,2), We can use minimum L, because the feedback loops in the replica branch will adjust the currents to give the correct output swing anyway.

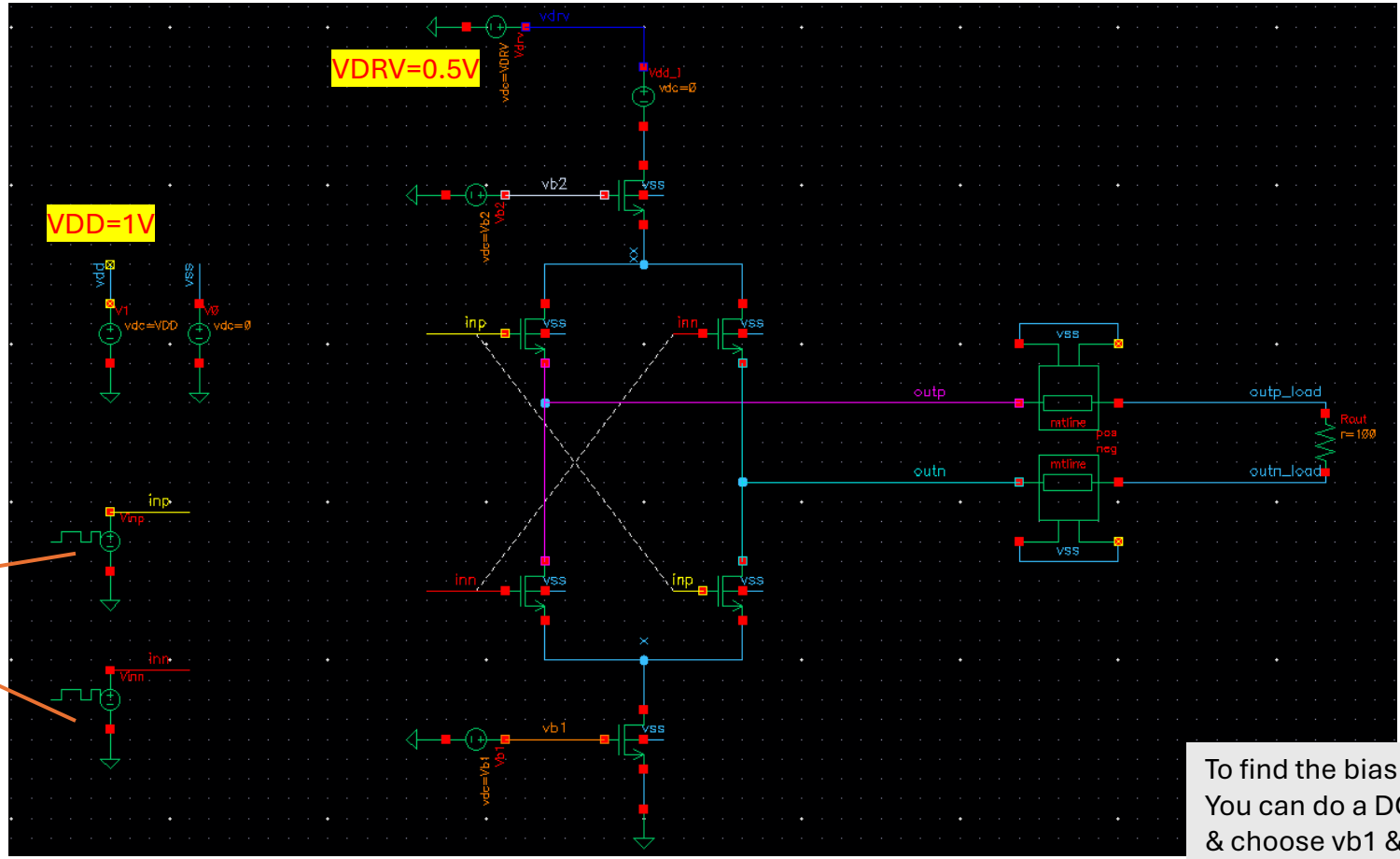
Mnp1,2 = Mnn1,2 = Mnp1,2_rep = Mnn1,2_rep : L = L_{MIN} , m=100x
Mn_source1,2 = Mn_source1,2_rep : L = L_{MIN} , m=200x

Testbenchs & Setups

- VDD = 1V
- Data-Rate = 1 Gb/s
- VSWING = 0.5V (pk2pk)

Testbench

A) Without Replica



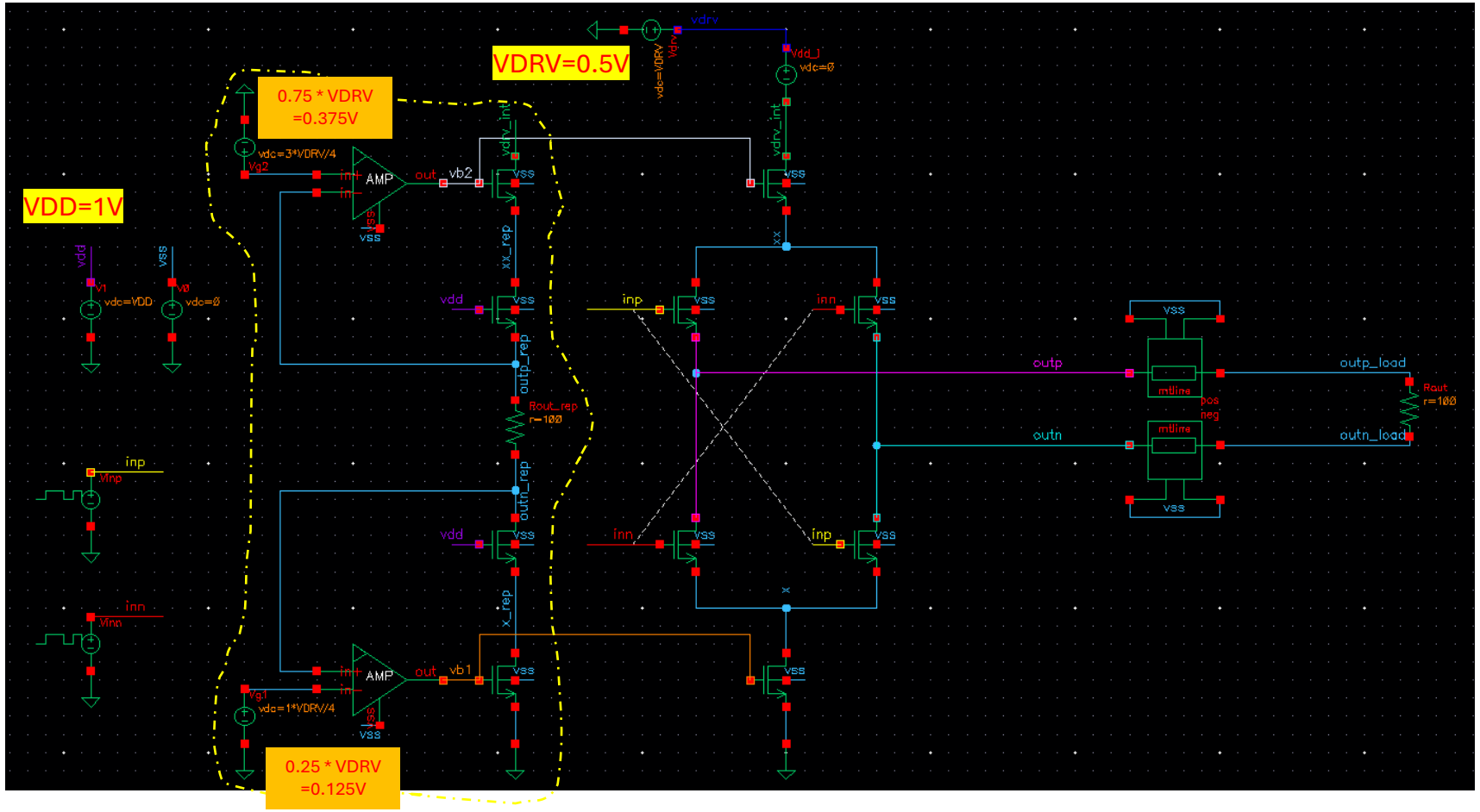
LIB: **analogLib**
CELL: **vprbs**

Zero value: **0 V** / 1 V
One value: **1 V** / 0 V
Bit period: **1 ns**
Rise/Fall times: **20 ps**
Edge type: **linear**
Trigger: **Internal**
LFSR Mode: **PN32**

To find the bias voltages vb1 & vb2,
You can do a DC-sweep with inp=1 & inn=0,
& choose vb1 & vb2 that would give outputs of ¾ V_{DRV} & ¼ V_{DRV}.

Testbench

B) With Replica

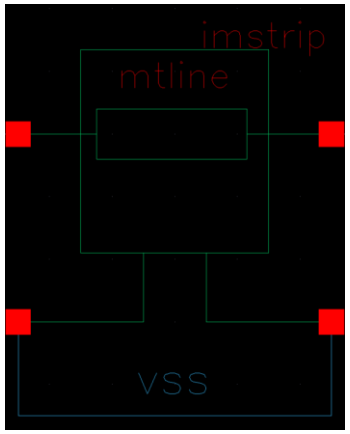


Channel Settings (mtline)

➔ For Zo = 50 Ohms:

$$Z_0 \approx \frac{87}{\sqrt{\varepsilon_r + 1.41}} \ln\left(\frac{5.98\,H}{0.8\,W + T}\right)$$

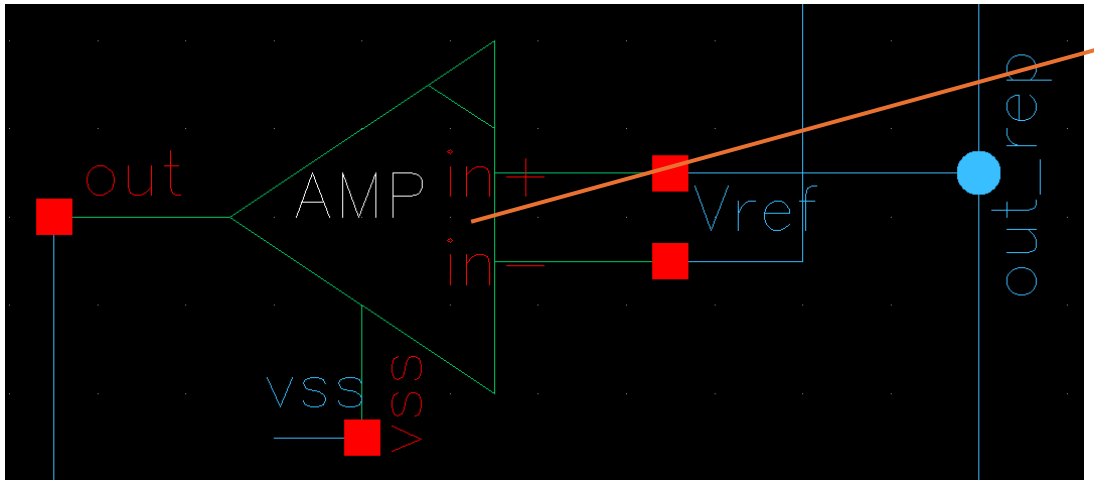
Dielectric_const = ε_r = 4.8
Dielectric_thickness = H = 360u
Line_width = W = 625u
Line_thickness = T = 17.78u

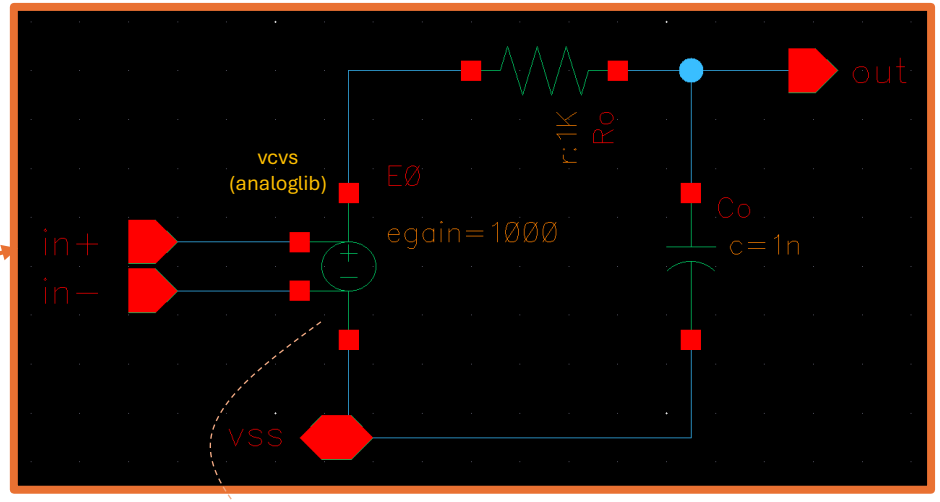


Library Name	analogLib
Cell Name	mtline

CDF Parameter	Value
Num of lines (excluding ref	1
Model name	
Physical length	100m M
Multiplicity factor	1
Max signal frequency	
Type of Input	FieldSolver
Generate noise?	no
Transmission line type	microstrip
Model type	wideband
Rel dielectic const of laye	4.8
Dielectric layer thickness	360u
Signal line width	625u
Signal line thickness	17.78u
Signal line spacing	

Ideal OpAmp

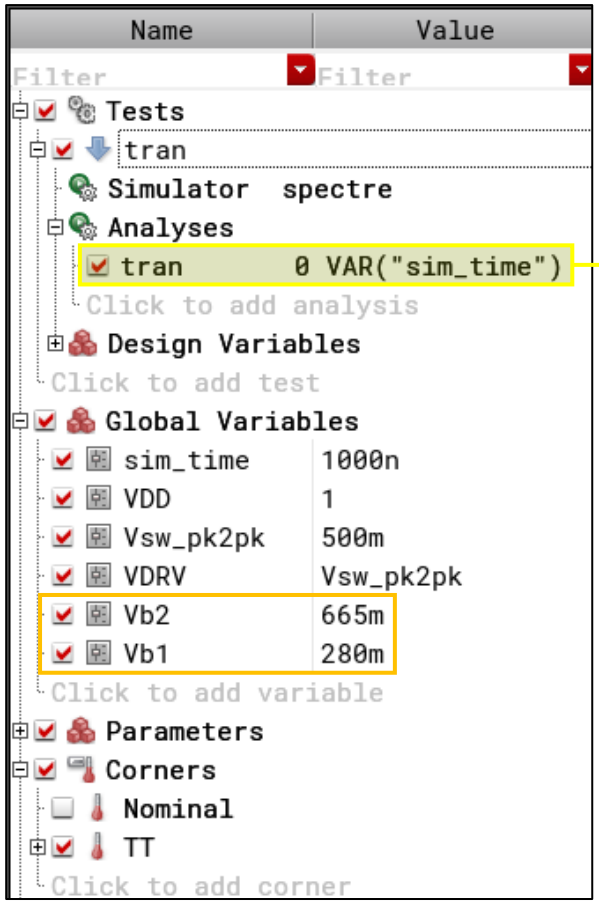


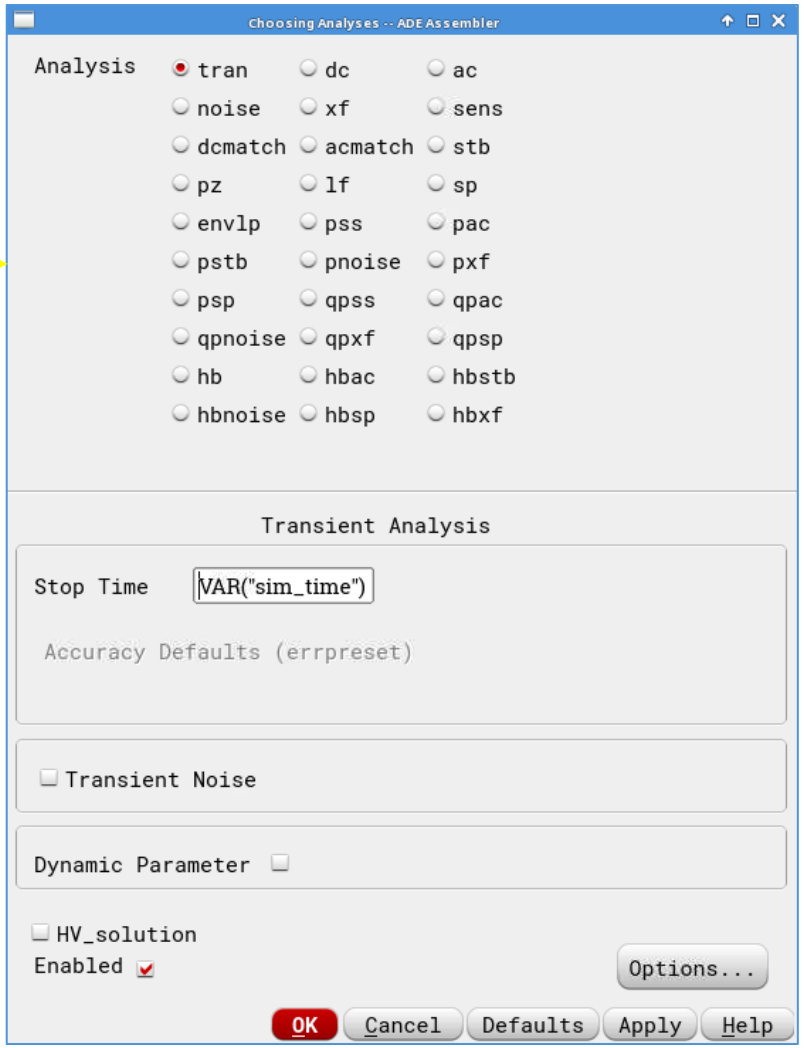


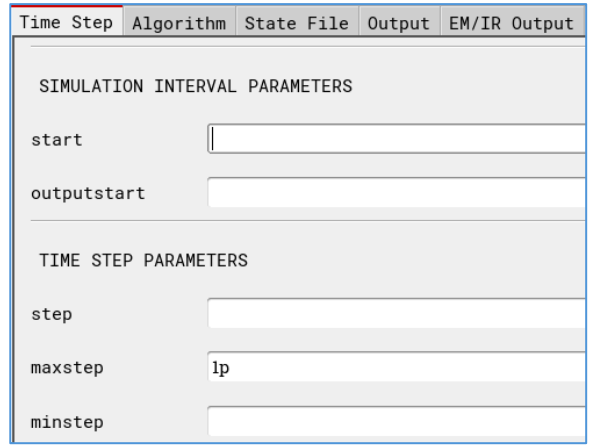
Library Name	analogLib
Cell Name	vcvs

CDF Parameter	Value
Type of transfer char	Linear / PWL
Smoothing Factor	
Voltage gain	1000
Multiplier	
Maximum Output Voltage	1
Minimum Output Voltage	0

Simulation Setup

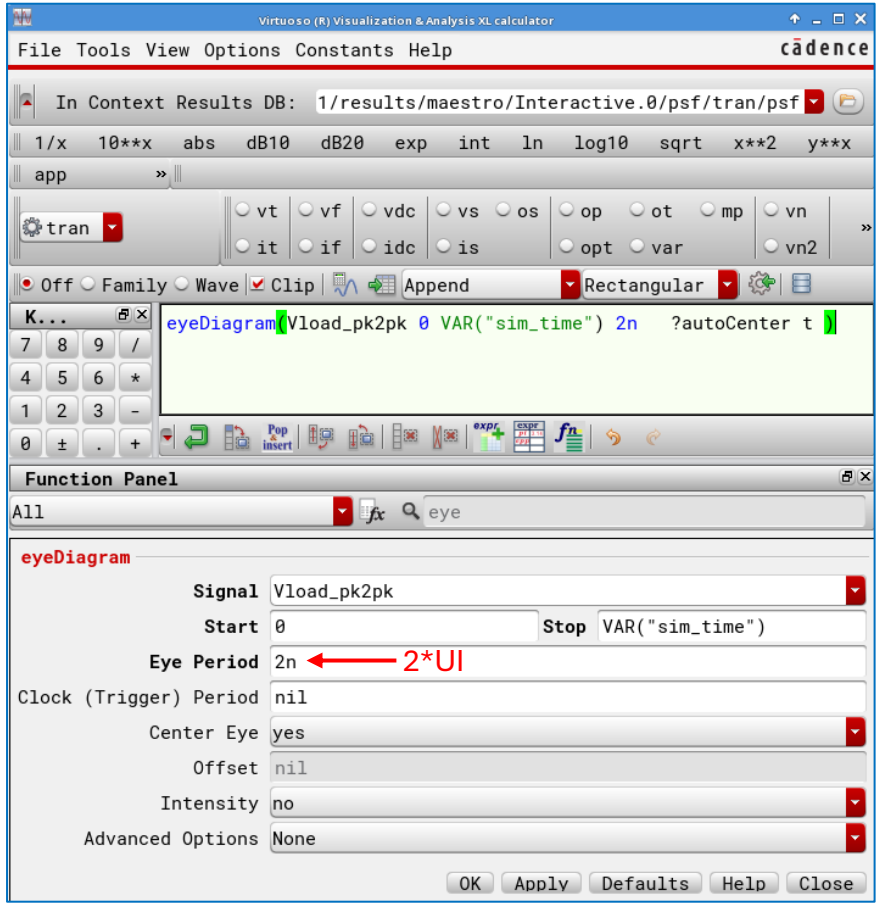






Measurements

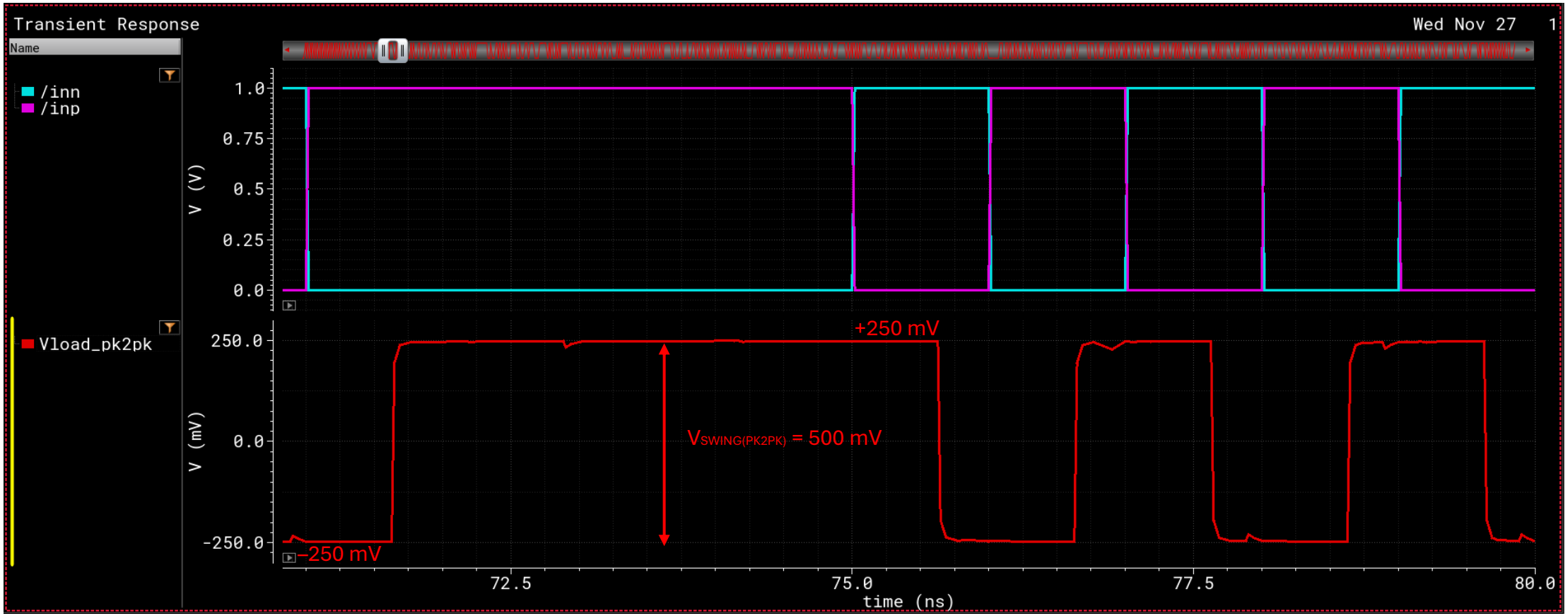
Name	Type	Details	EvalType
Filter	Filter	Filter	Filter
*** Voltages ***	expr		point
	signal	/inp	point
	signal	/inn	point
	signal	/outp	point
	signal	/outn	point
	signal	/outp_load	point
	signal	/outn_load	point
	signal	/x	point
	signal	/xx	point
	signal	/vdrv	point
	signal	/vb2	point
	signal	/vb1	point
	signal	/x_rep	point
	signal	/xx_rep	point
	signal	/outp_rep	point
	signal	/outn_rep	point
*** Currents ***	expr		point
/Vdd_I/PLUS_I	signal …	/Vdd_I/PLUS	point
/Rout/PLUS_I	signal …	/Rout/PLUS	point
*** Outputs ***	expr		point
Vtxout_pk2pk	expr	(VT("/outp") - VT("/outn"))	point
Vtxout_eye	expr	eyeDiagram(Vtxout_pk2pk 0 VAR("sim_time") 2e-09 ?autoCenter t)	point
Vload_pk2pk	expr	(VT("/outp_load") - VT("/outn_load"))	point
Vload_eye	expr	eyeDiagram(Vload_pk2pk 0 VAR("sim_time") 2e-09 ?autoCenter t)	point



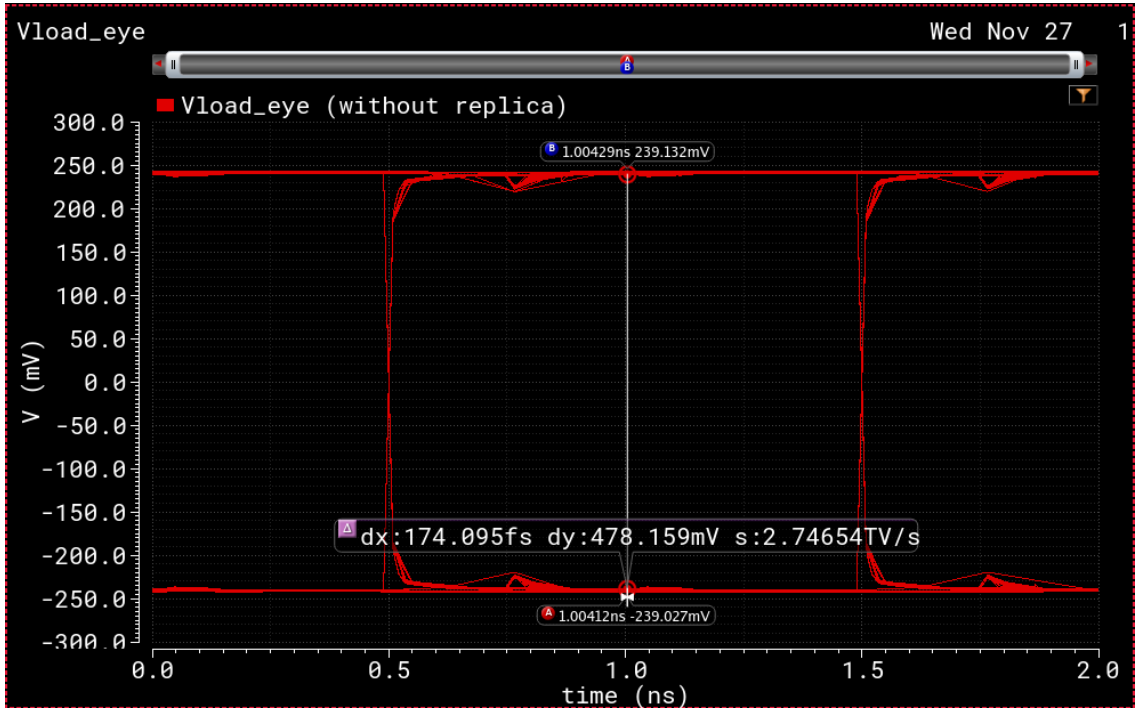
eyeDiagram(VT("/outp_load")-VT("/outn_load") 0 VAR(“sim_time") 2n ?autoCenter t)

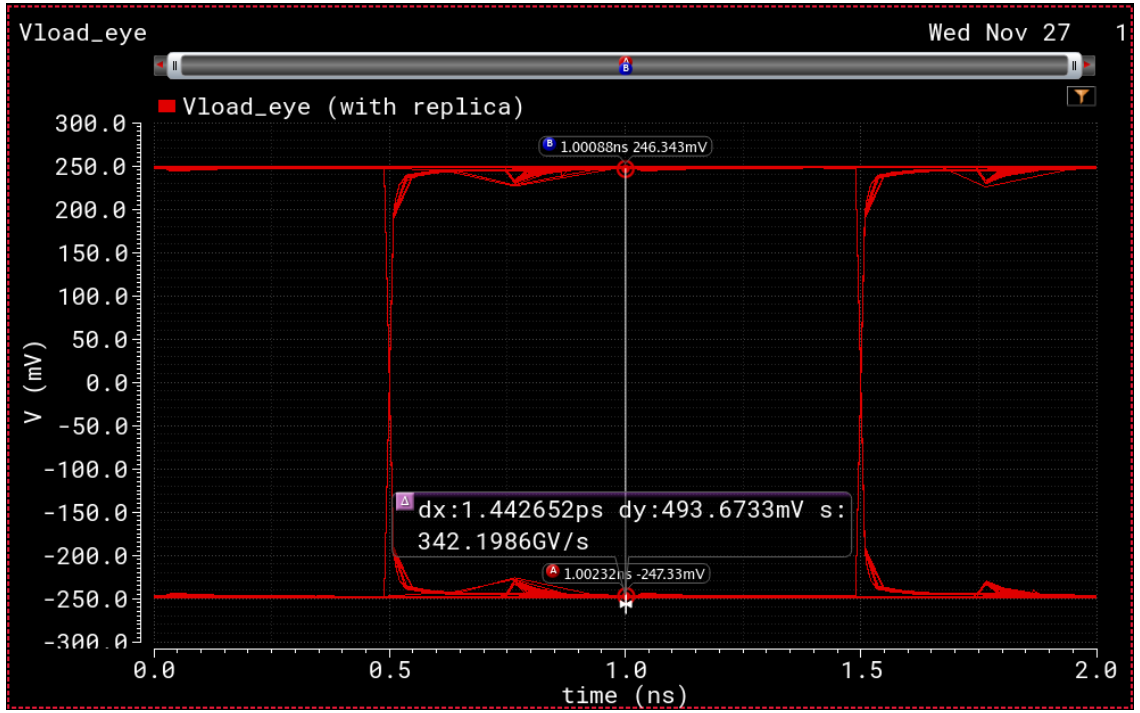
Simulations & Results

Waveforms


Transient Response
Wed Nov 27
1
Name
/inn
/inp
Vload_pk2pk
1.0
0.75
0.5
0.25
0.0
V (V)
250.0
0.0
-250.0
V (mV)
+250 mV
VSWING(PK2PK) = 500 mV
−250 mV
72.5
75.0
77.5
80.0
time (ns)

Waveforms (Eye-Diagrams)





No Replica:

$V_{SW(pk2pk)}$ = 478.16 mV

With Replica:

$V_{SW(pk2pk)}$ = 493.67 mV

➔ More Accurate Swing, at the expense of additional power drawn by an extra branch & the OpAmps

(For more info on how to measure Eye Diagrams)

Current Consumption

- Total current drawn = 5 mA

  (2.5 mA from main driver + 2.5 mA from Replica branch)
  (OpAmps not included)