Analog cell simulation

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Requirements

1) operate with nominal capacitive load of 400fF, about half parasitic to ground, and half to neighors

2) end-of-lifetime signal is 10Ke after 10**15 n equiv at 600V bias in oxygenated sensors. This means we want an in-time threshold of about 4Ke for full efficiency.

3) threshold dispersion less than about 200e (after tuning)

4) noise less than about 300e after irradiation, including series noise from 400fF and parallel noise from leakage current.

5) leakage current tolerance of up to 100nA

6) timewalk (time slewing from large charge to small charge) of less than 20ns for "in-time" threshold of 4Ke. For example, operate with a threshold of 3Ke and an overdrive for 20ns slewing of 1Ke.

7) noise occupancy less than 10-6 hits/crossing/pixel

8) double pulse resolution which can be tuned down to 500ns

9) modest charge measurement resolution of 4-5 bits

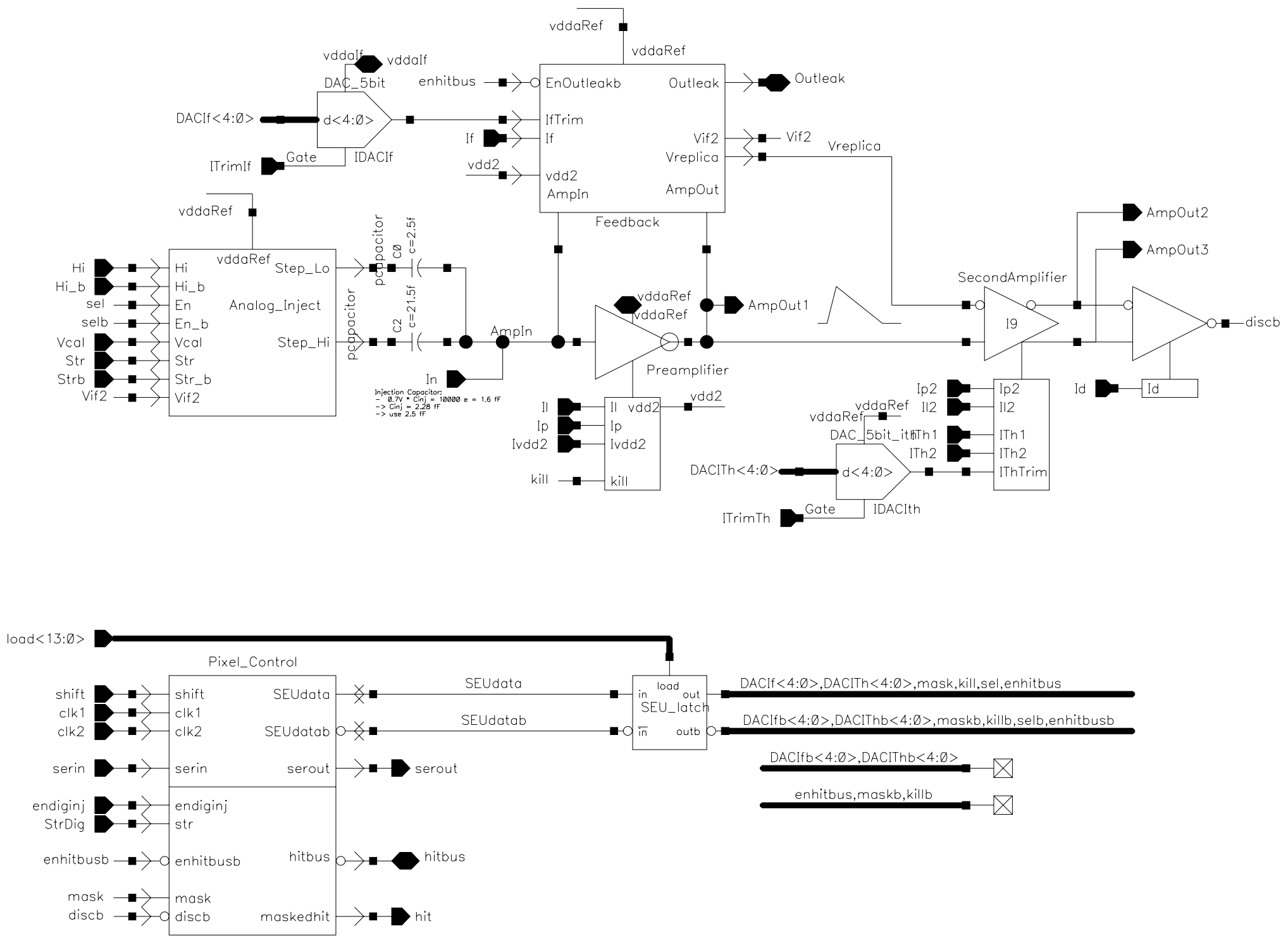
10) cross-talk less than 5-10% (pulse height in neighbor channel of 10-20 times threshold required to fire pixel)

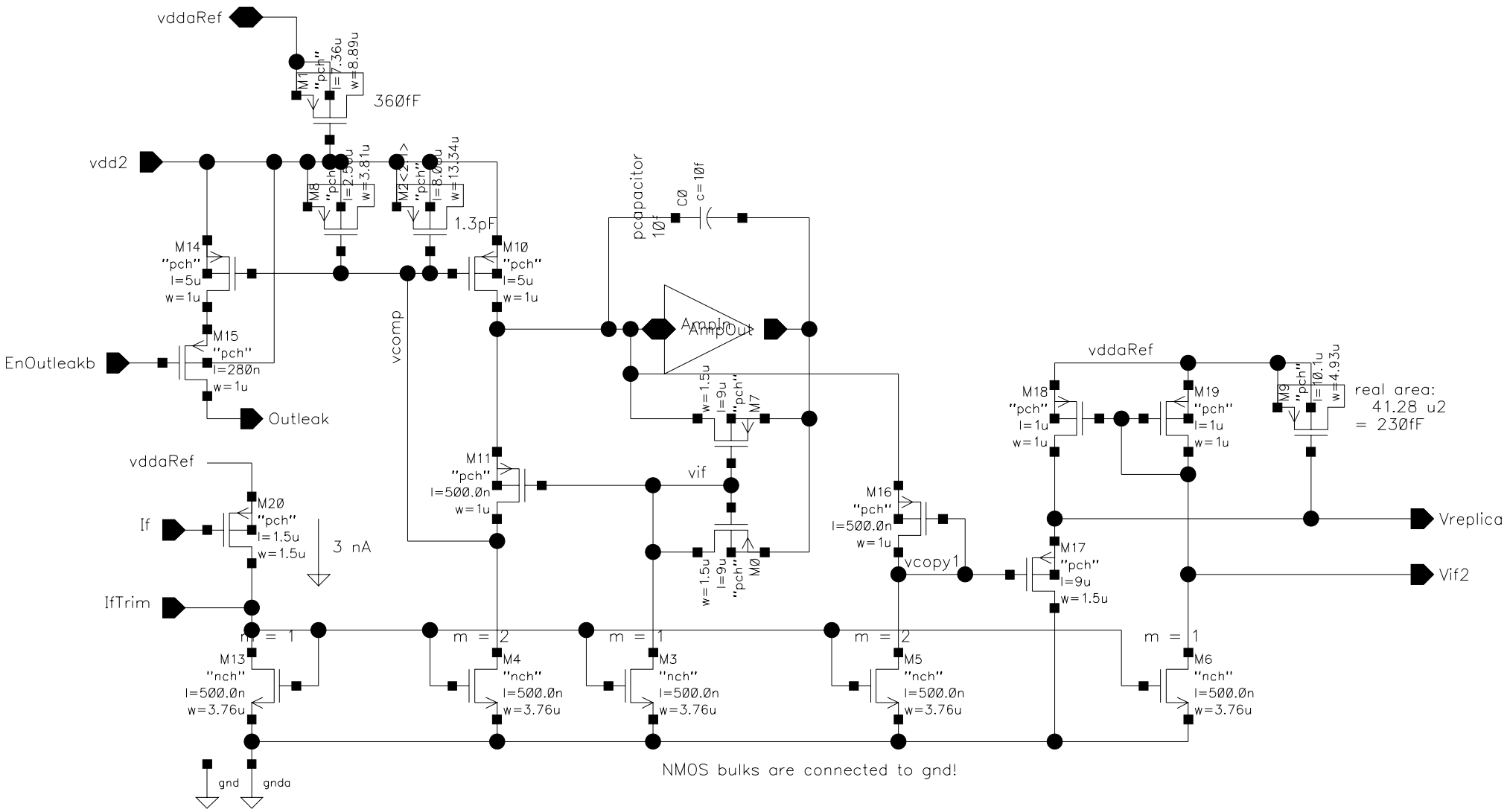
11) threshold range of up to at least 6Ke

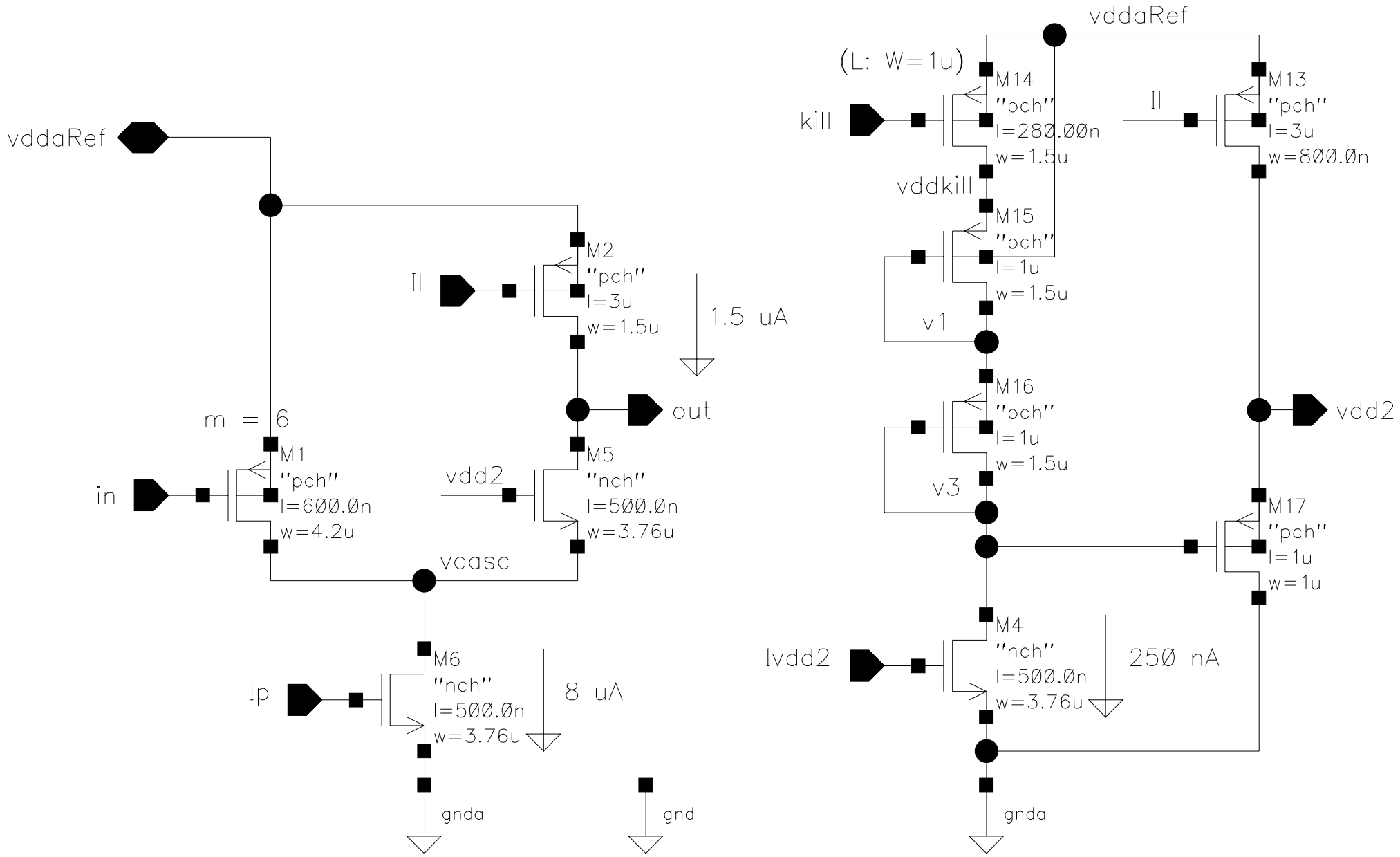
Analog cell

- Main goals:
  - Full operation with a single analog power supply of 1.6V
  - Single ended for this first “secure” cell but with special emphasis on high PSRR.
  - 2 stage based cell
    - First amp with small gain -> low input impedance
    - Fully differential second stage with high gain -> saturation at 12ke$^-$
  - Same current as for DMILL & HONEYWELL analog cell (-> half of the power)
  - New scheme of leakage current compensation (only a 1u/0.5u and a 1u/1u PMOS added to the usual 1u/6u PMOS current mirror)

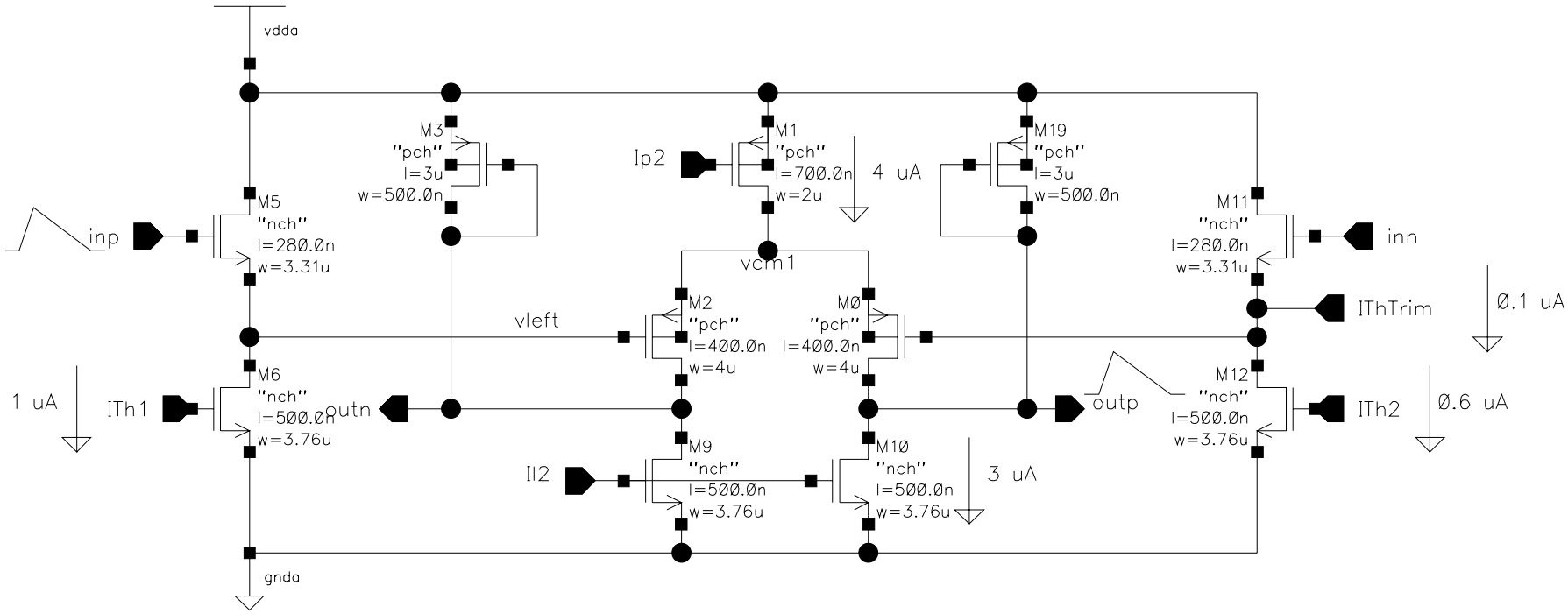
Schematics

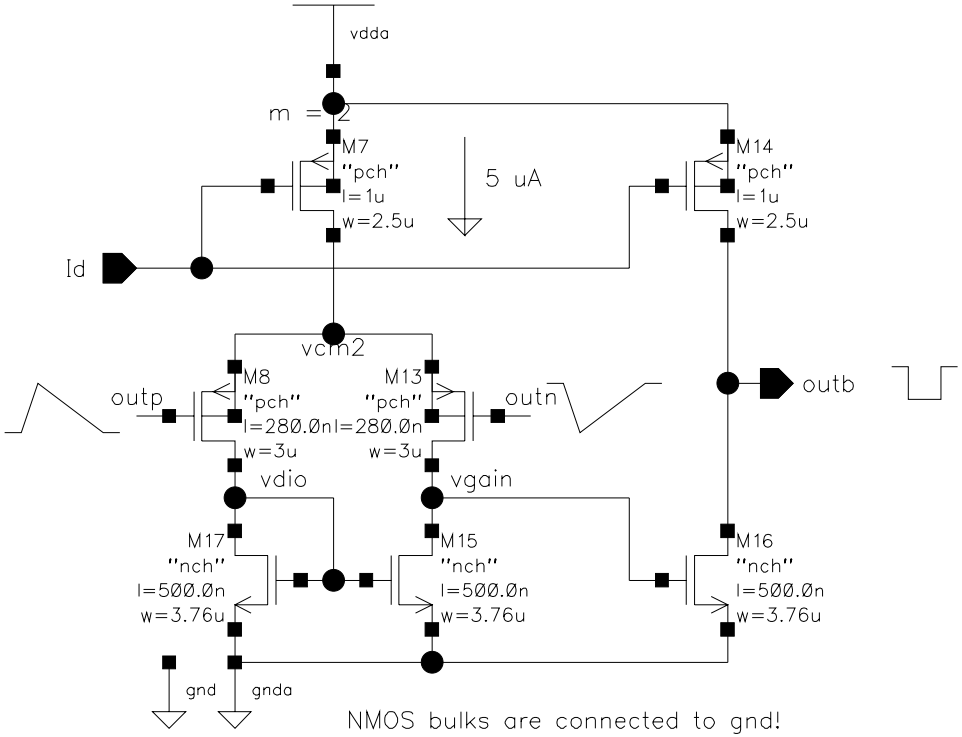

vddaRef
vddaIf
DAC_5bit
enhitbus
EnOutleakb
Outleak
DACIf<4:0>
d<4:0>
IfTrim
If
Vif2
Vreplica
ITrimIf
Gate
IDACIf
vdd2
AmpIn
AmpOut
Feedback
AmpOut2
AmpOut3
Hi
Hi_b
sel
selb
Vcal
Str
Strb
Vif2
En
En_b
Step_Lo
Step_Hi
Analog_Inject
pcapacitor
C0
c=2.5f
C2
c=21.5f
In
Injection Capacitor:
- 0.7V * Cinj = 10000 e = 1.6 fF
-> Cinj = 2.28 fF
-> use 2.5 fF
AmpOut1
SecondAmplifier
I9
Preamplifier
discb
Il
Ip
Ivdd2
kill
Ip2
Il2
ITh1
ITh2
IThTrim
Id
DAC_5bit_ith
DACITh<4:0>
ITrimTh
IDACIth
load<13:0>
Pixel_Control
shift
clk1
clk2
serin
endiginj
StrDig
enhitbusb
mask
discb
SEUdata
SEUdatab
serout
hitbus
maskedhit
hit
SEU_latch
load
in
out
outb
DACIf<4:0>,DACITh<4:0>,mask,kill,sel,enhitbus
DACIfb<4:0>,DACIThb<4:0>,maskb,killb,selb,enhitbusb
DACIfb<4:0>,DACIThb<4:0>
enhitbus,maskb,killb

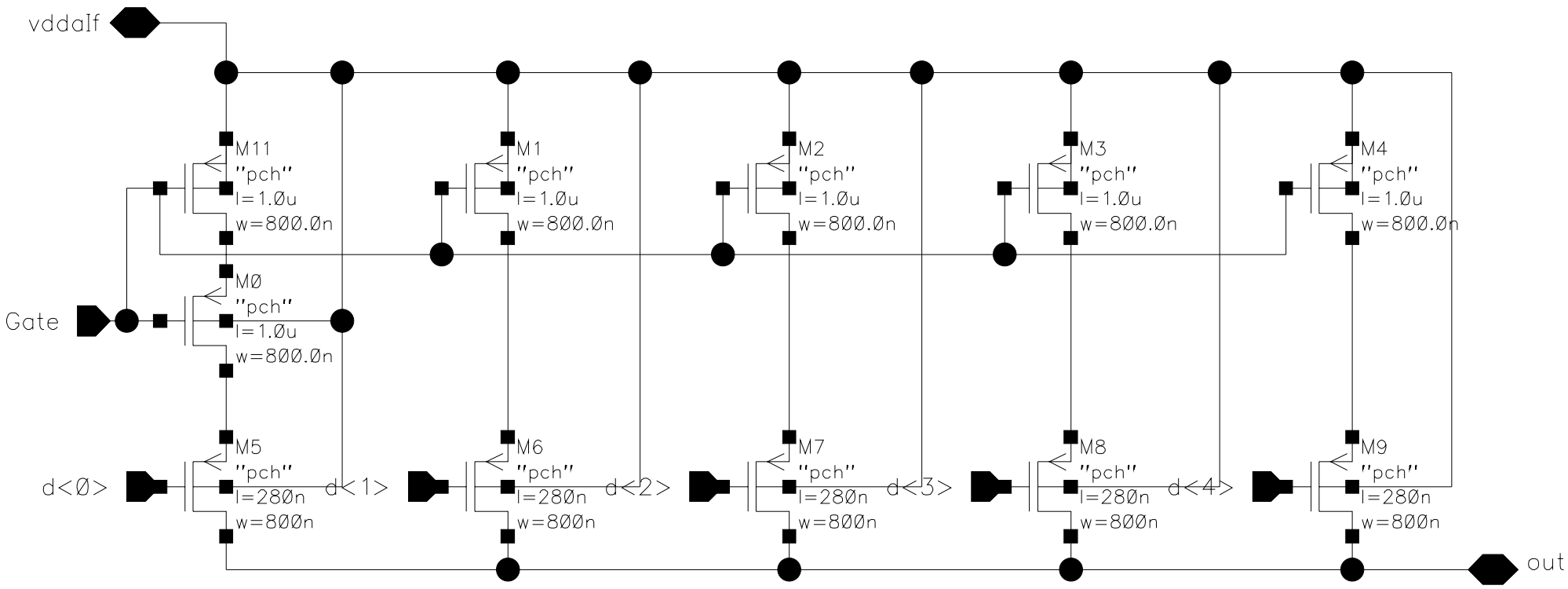

vddaRef
M1
"pch"
l=7.36u
w=8.89u
360fF
vdd2
M8
"pch"
l=2.50u
w=3.81u
M2<2>
"pch"
l=8.00u
w=13.34u
1.3pF
pcapacitor
10f
C0
c=10f
M14
"pch"
l=5u
w=1u
M10
"pch"
l=5u
w=1u
M15
"pch"
l=280n
w=1u
EnOutleakb
Outleak
vcomp
AmpIn
AmpOut
w=1.5u
l=9u
"pch"
M7
vddaRef
M18
"pch"
l=1u
w=1u
M19
"pch"
l=1u
w=1u
M9
"pch"
l=10.1u
w=4.93u
real area:
41.28 u2
= 230fF
M11
"pch"
l=500.0n
w=1u
vif
vddaRef
M20
"pch"
l=1.5u
w=1.5u
If
3 nA
IfTrim
M16
"pch"
l=500.0n
w=1u
vcopy1
M17
"pch"
l=9u
w=1.5u
Vreplica
Vif2
w=1.5u
l=9u
"pch"
M0
m = 1
m = 2
m = 1
m = 2
m = 1
M13
"nch"
l=500.0n
w=3.76u
M4
"nch"
l=500.0n
w=3.76u
M3
"nch"
l=500.0n
w=3.76u
M5
"nch"
l=500.0n
w=3.76u
M6
"nch"
l=500.0n
w=3.76u
gnd
gnda
NMOS bulks are connected to gnd!

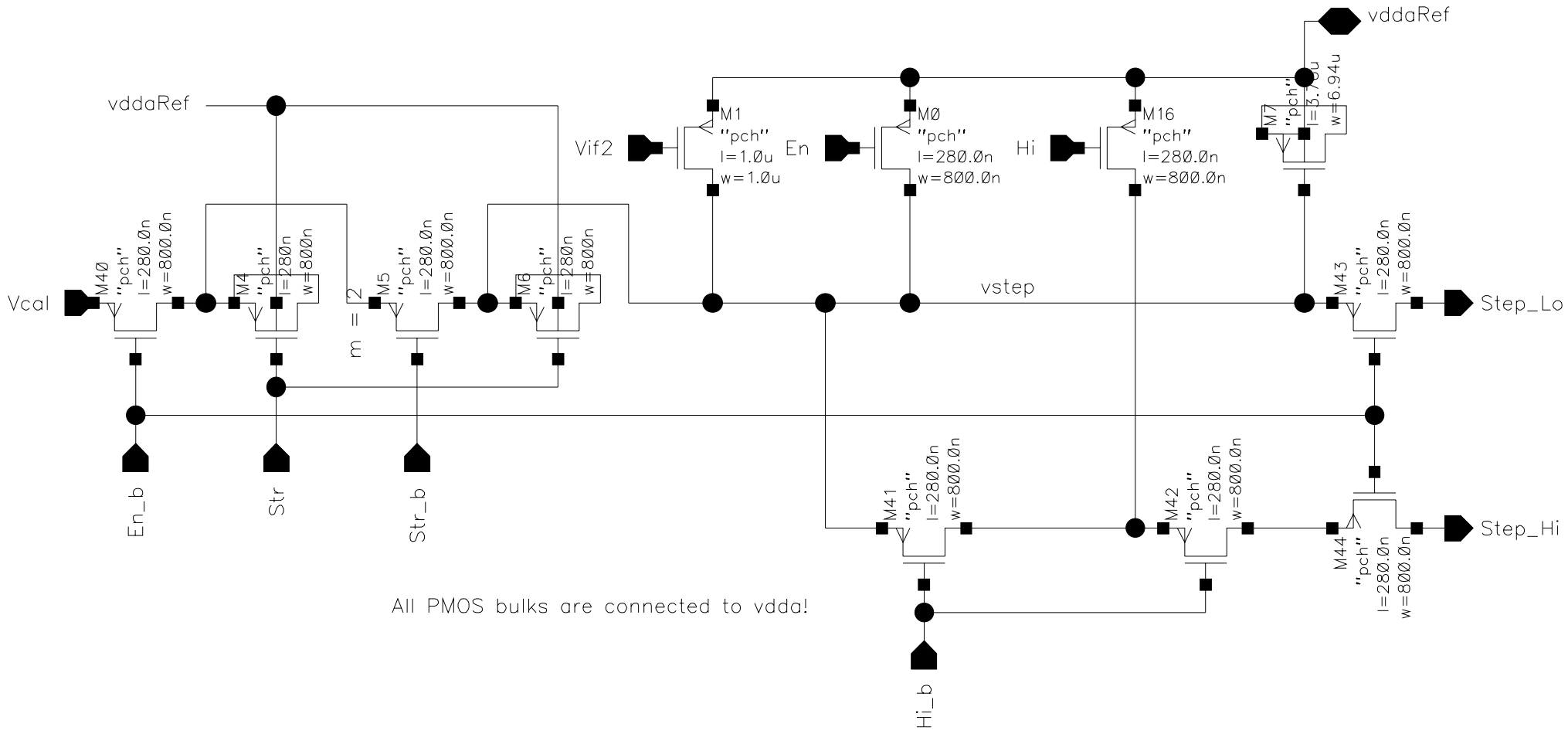


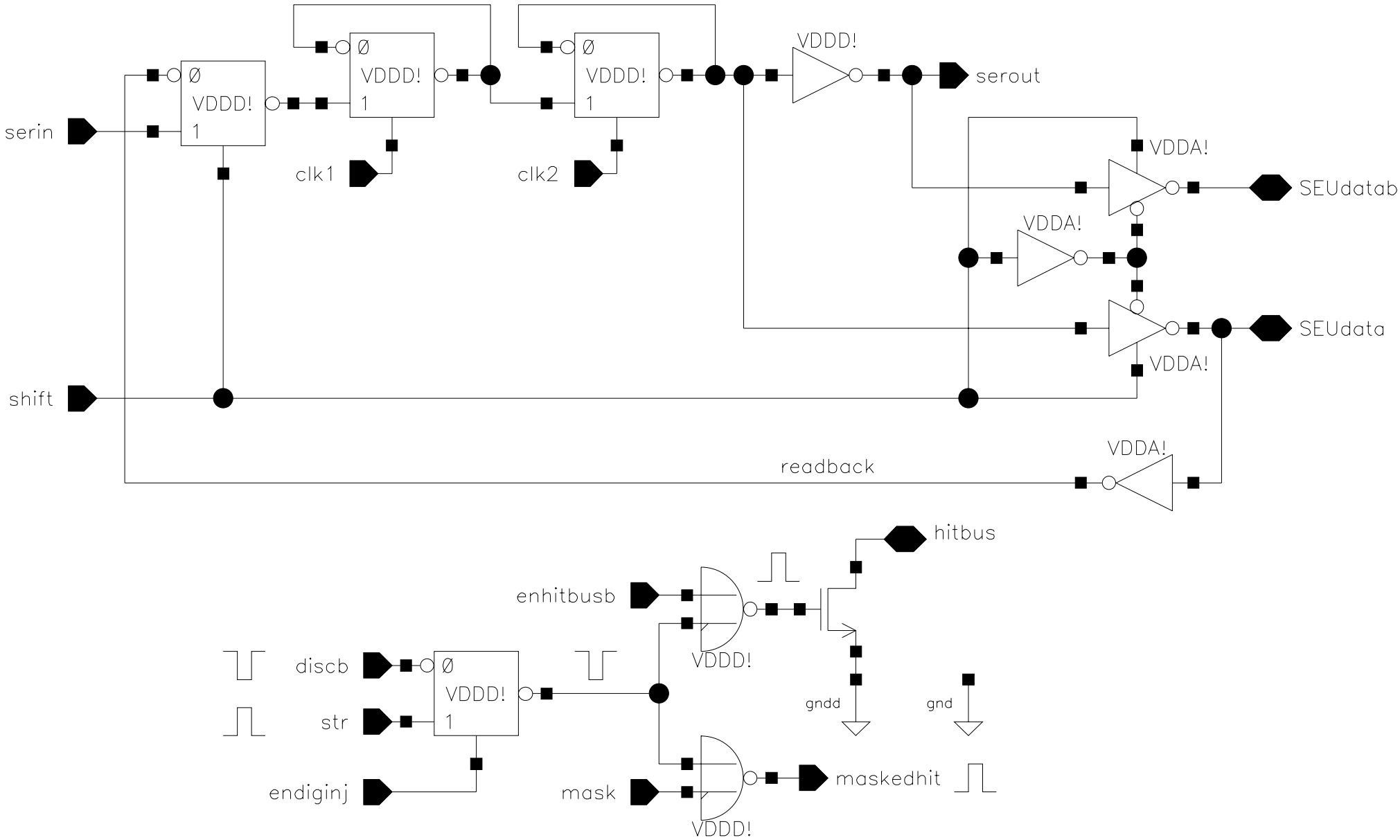
NMOS bulks are connected to gnd!

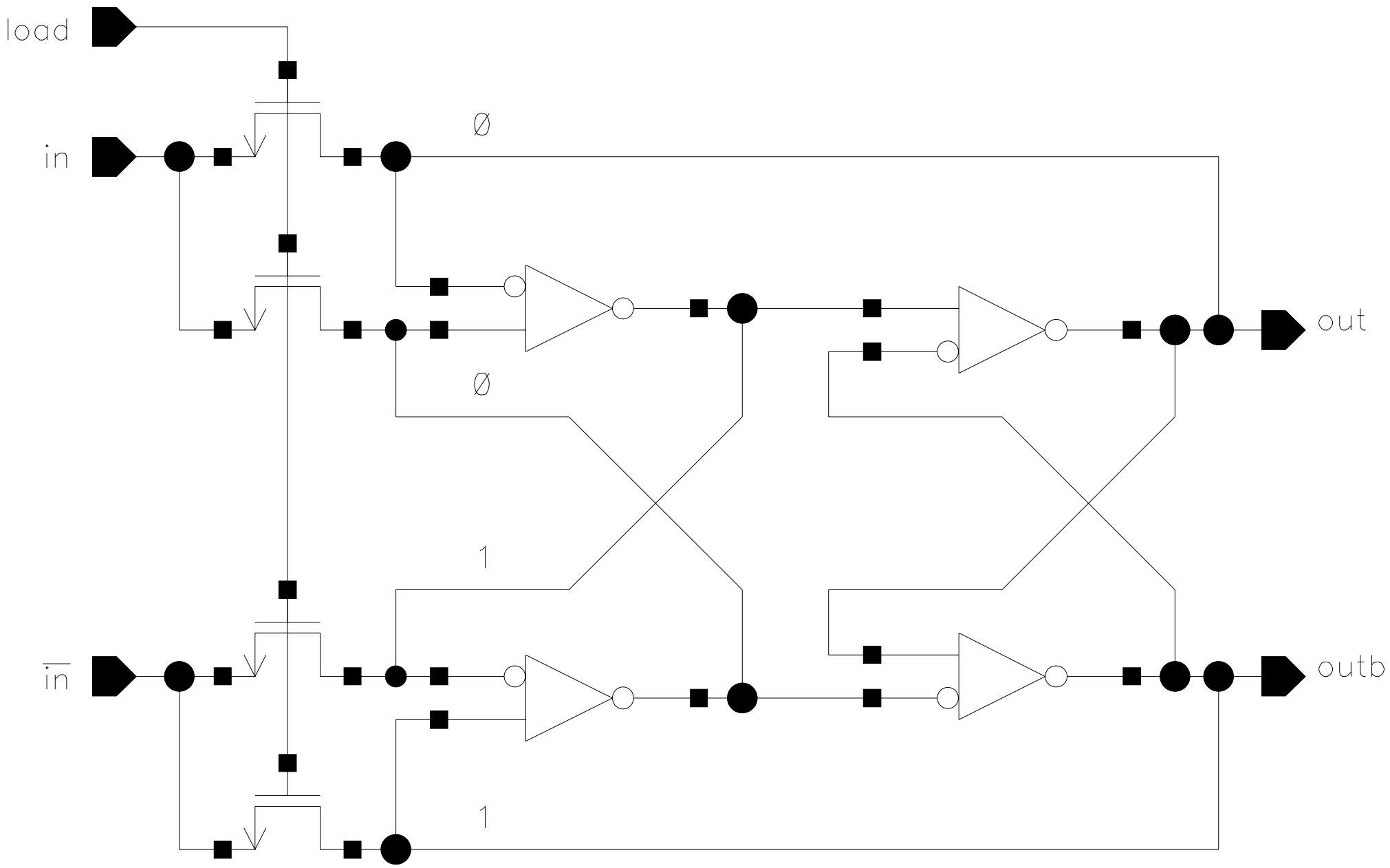

vdda
M3
"pch"
l=3u
w=500.0n
M1
"pch"
l=700.0n
w=2u
Ip2
4 uA
M19
"pch"
l=3u
w=500.0n
M5
"nch"
l=280.0n
w=3.31u
inp
M11
"nch"
l=280.0n
w=3.31u
inn
vcm1
M2
"pch"
l=400.0n
w=4u
M0
"pch"
l=400.0n
w=4u
vleft
IThTrim
0.1 uA
M6
"nch"
l=500.0n
w=3.76u
1 uA
ITh1
outn
outp
M12
"nch"
l=500.0n
w=3.76u
ITh2
0.6 uA
M9
"nch"
l=500.0n
w=3.76u
M10
"nch"
l=500.0n
w=3.76u
Il2
3 uA
gnda

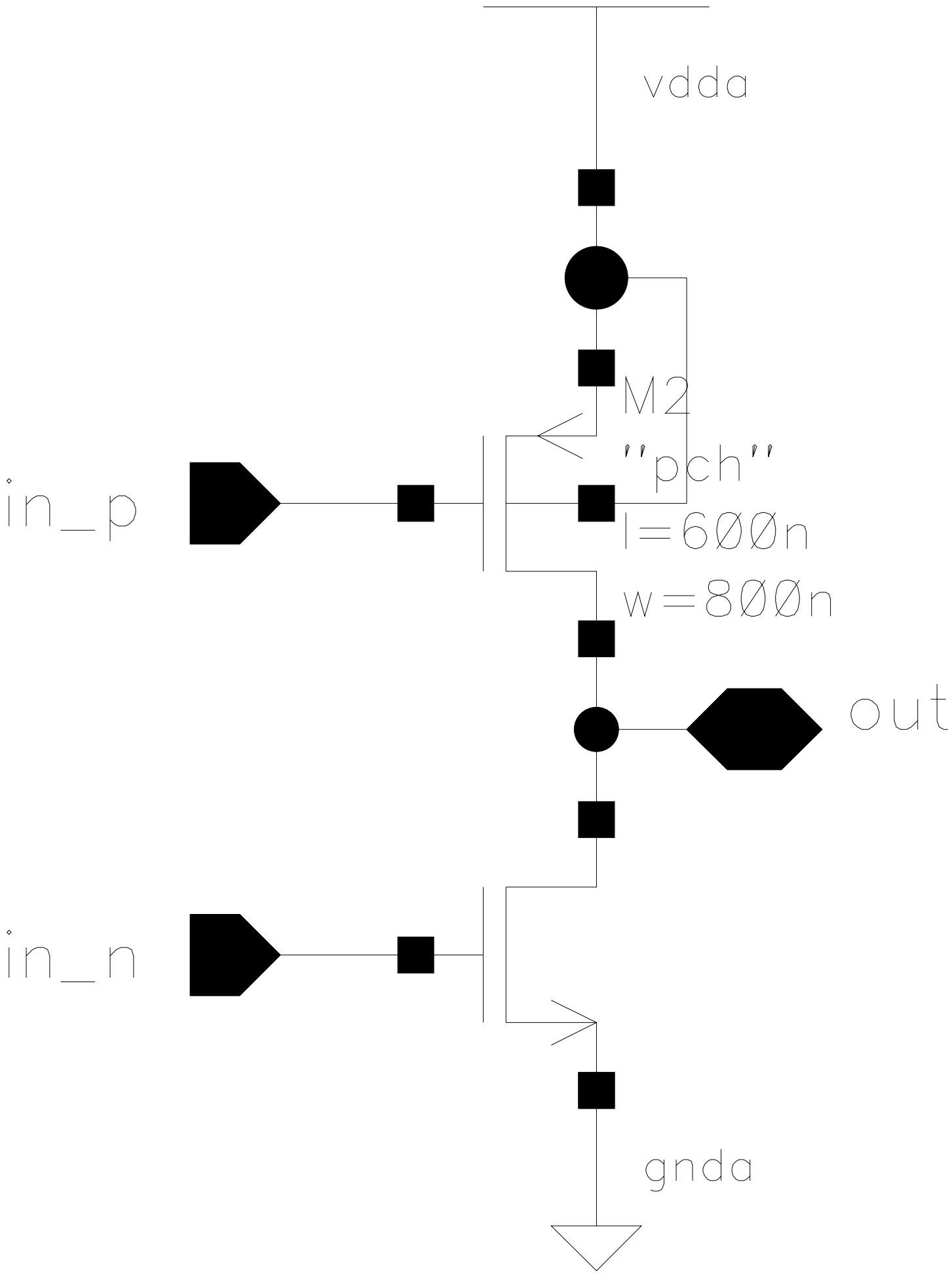

vdda
m =2
M7
"pch"
l=1u
w=2.5u
5 uA
M14
"pch"
l=1u
w=2.5u
Id
vcm2
M8
"pch"
l=280.0n
w=3u
M13
"pch"
l=280.0n
w=3u
outp
outn
outb
vdio
vgain
M17
"nch"
l=500.0n
w=3.76u
M15
"nch"
l=500.0n
w=3.76u
M16
"nch"
l=500.0n
w=3.76u
gnd
gnda
NMOS bulks are connected to gnd!

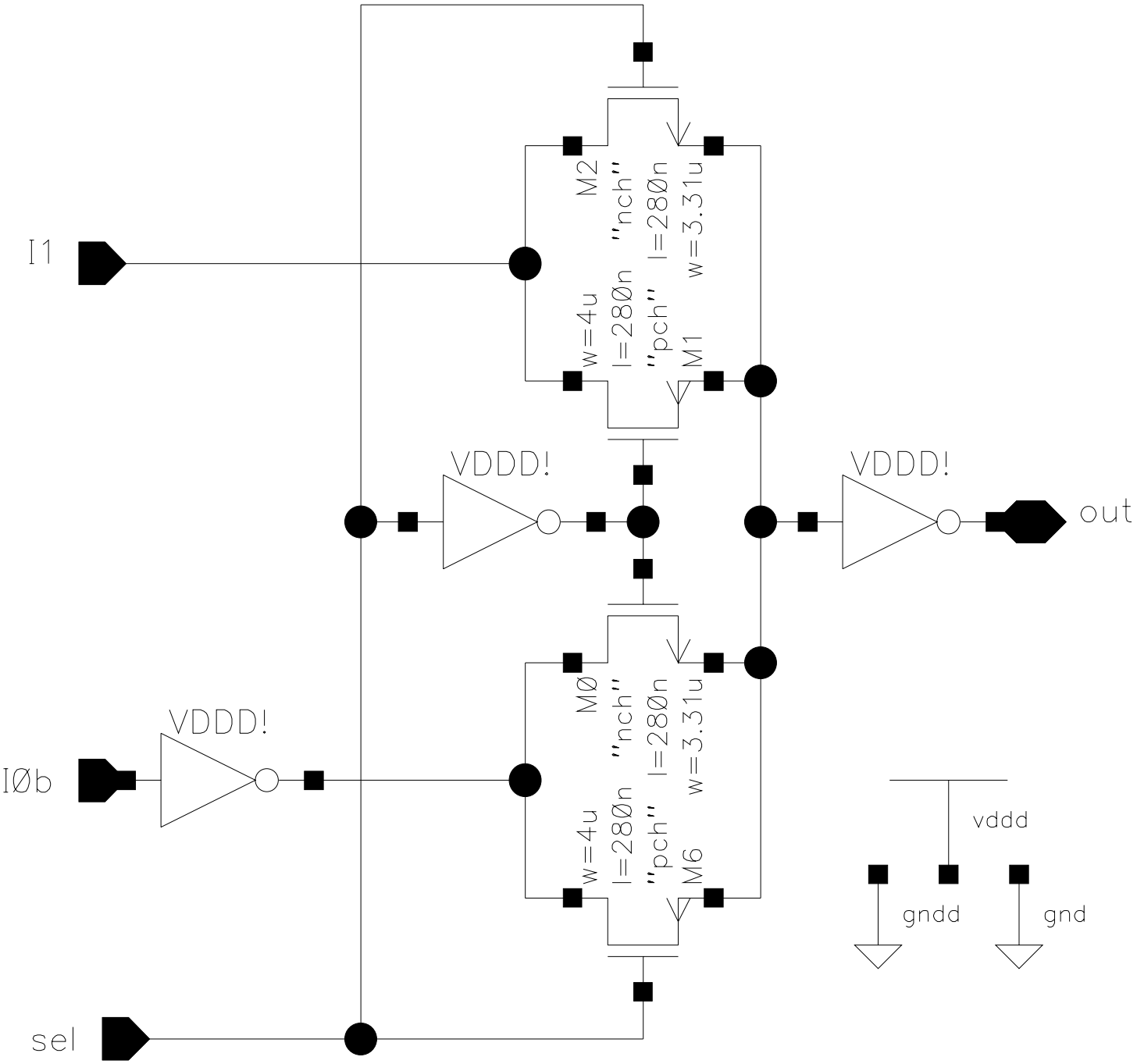

vddaIf
M11
"pch"
l=1.0u
w=800.0n
M1
"pch"
l=1.0u
w=800.0n
M2
"pch"
l=1.0u
w=800.0n
M3
"pch"
l=1.0u
w=800.0n
M4
"pch"
l=1.0u
w=800.0n
M0
"pch"
l=1.0u
w=800.0n
Gate
M5
"pch"
l=280n
w=800n
d<0>
d<1>
M6
"pch"
l=280n
w=800n
d<2>
M7
"pch"
l=280n
w=800n
d<3>
M8
"pch"
l=280n
w=800n
d<4>
M9
"pch"
l=280n
w=800n
out


vddaRef
vddaRef
Vif2
M1
"pch"
l=1.0u
w=1.0u
En
M0
"pch"
l=280.0n
w=800.0n
Hi
M16
"pch"
l=280.0n
w=800.0n
M7
"pch"
l=3.70u
w=6.94u
Vcal
M40
"pch"
l=280.0n
w=800.0n
M4
"pch"
l=280n
w=800n
m = 2
M5
"pch"
l=280.0n
w=800.0n
M6
"pch"
l=280n
w=800n
vstep
M43
"pch"
l=280.0n
w=800.0n
Step_Lo
En_b
Str
Str_b
M41
"pch"
l=280.0n
w=800.0n
M42
"pch"
l=280.0n
w=800.0n
M44
"pch"
l=280.0n
w=800.0n
Step_Hi
All PMOS bulks are connected to vdda!
Hi_b

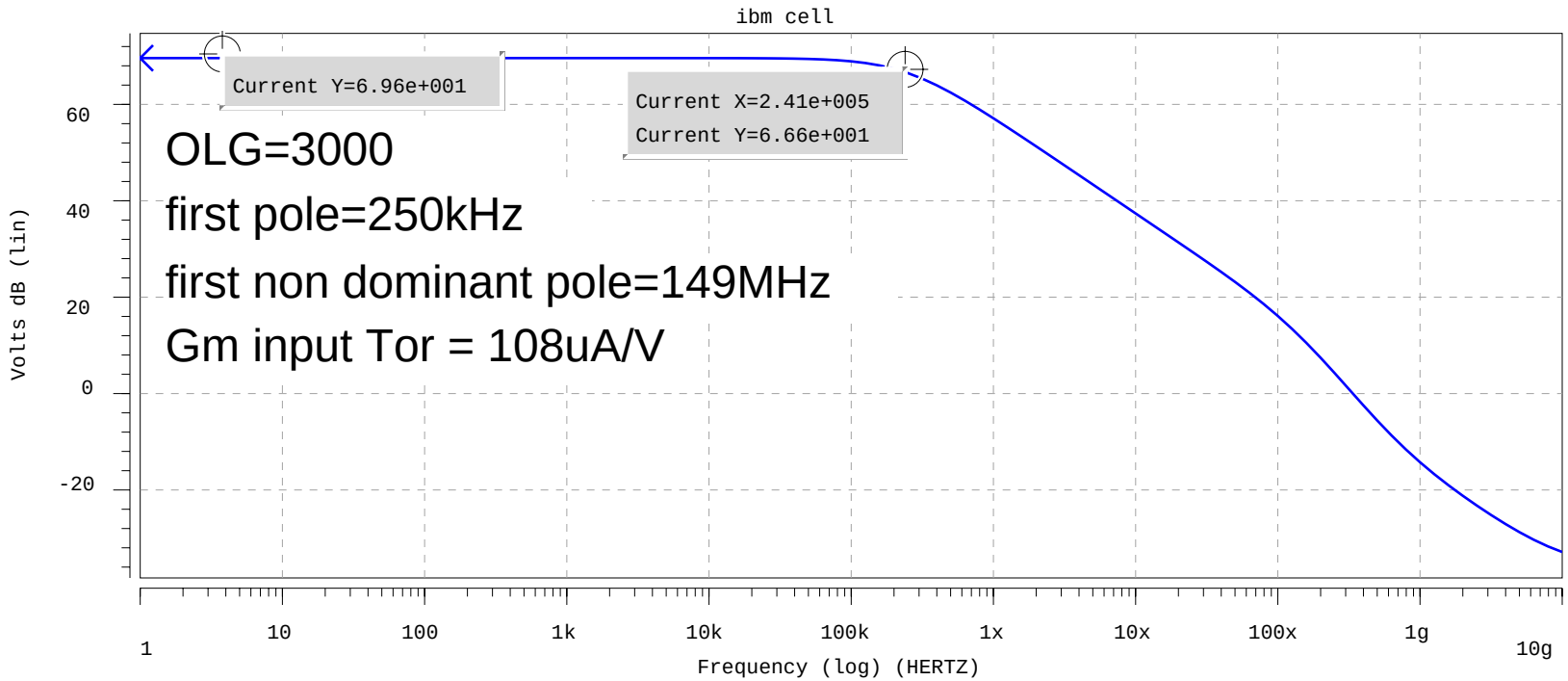

serin
Ø
VDDD!
1
clk1
clk2
VDDD!
serout
VDDA!
SEUdatab
SEUdata
shift
readback
hitbus
enhitbusb
discb
str
endiginj
mask
maskedhit
gndd
gnd

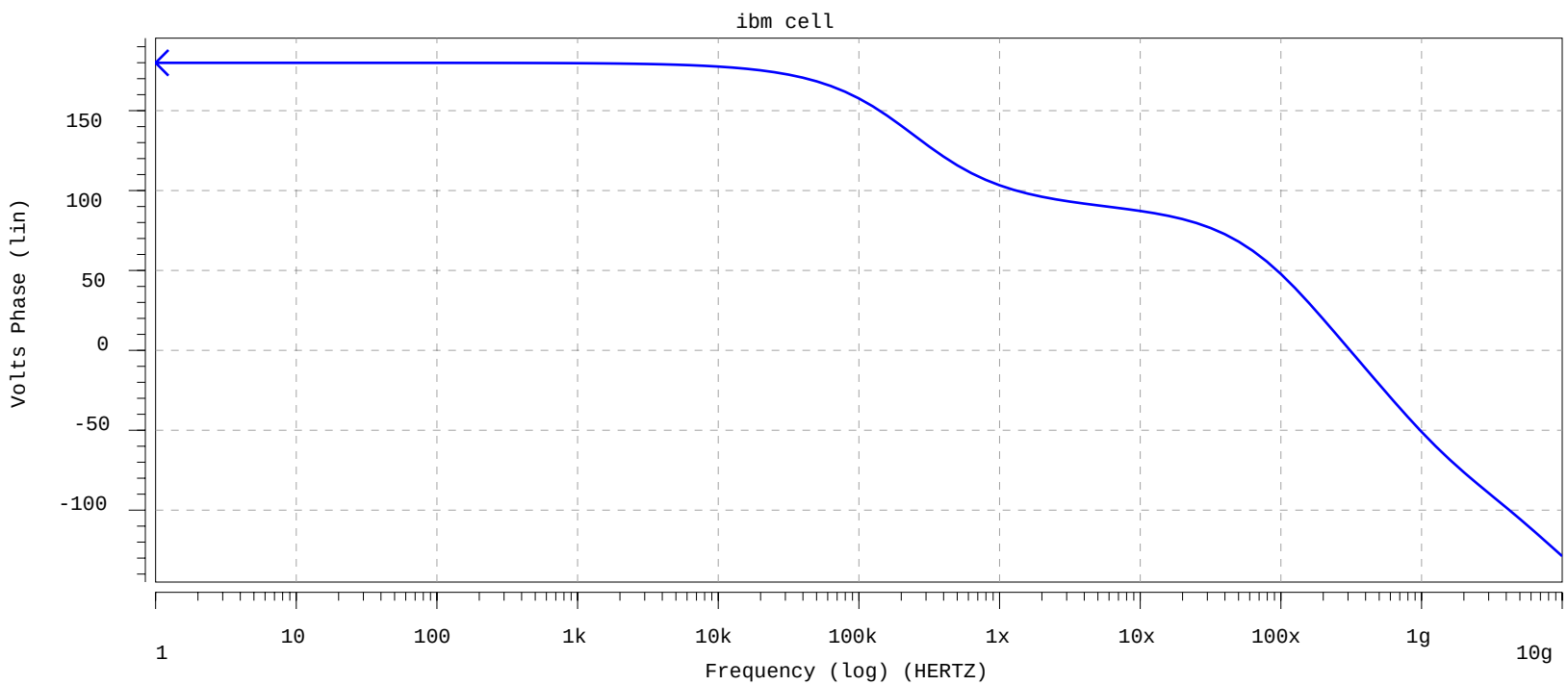

load
in
Ø
Ø
out
1
in
outb
1

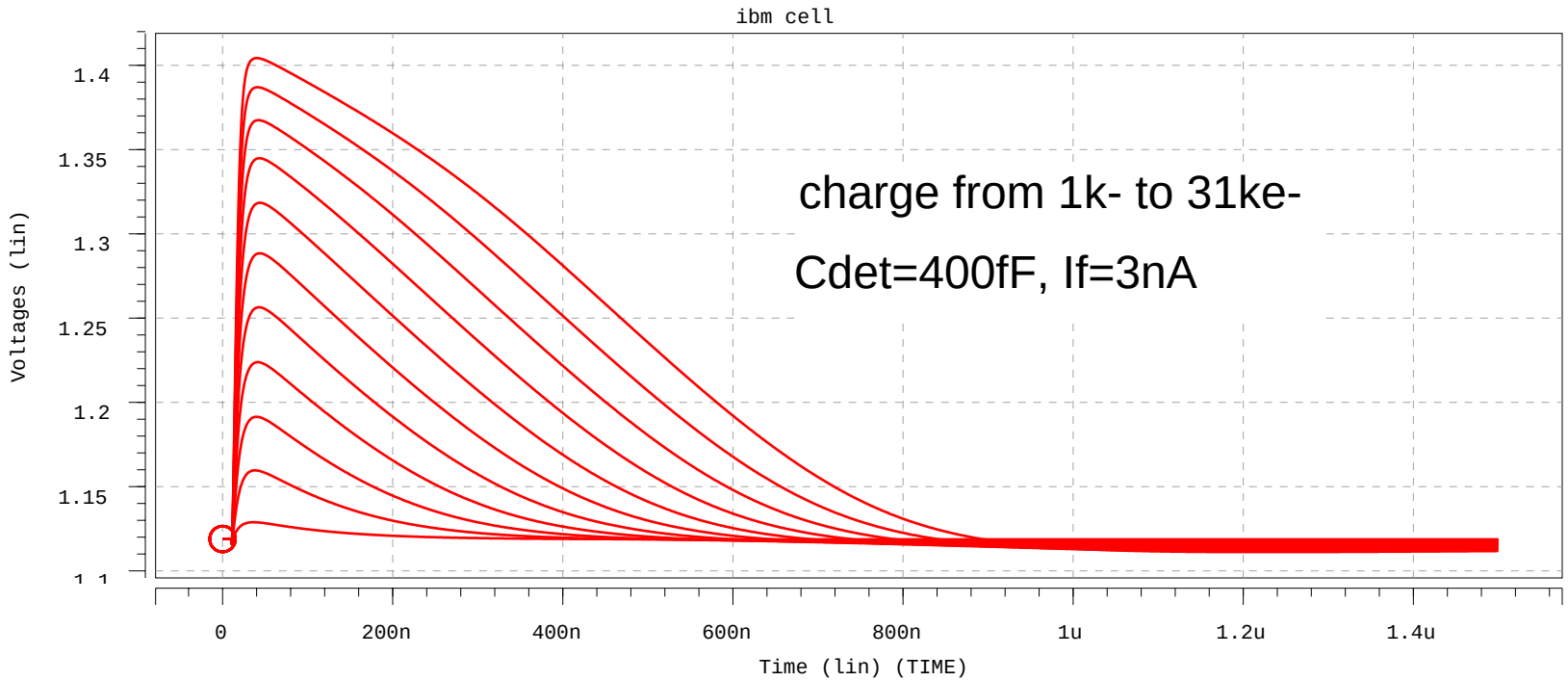

vdda
M2
"pch"
l=600n
w=800n
in_p
out
in_n
gnda

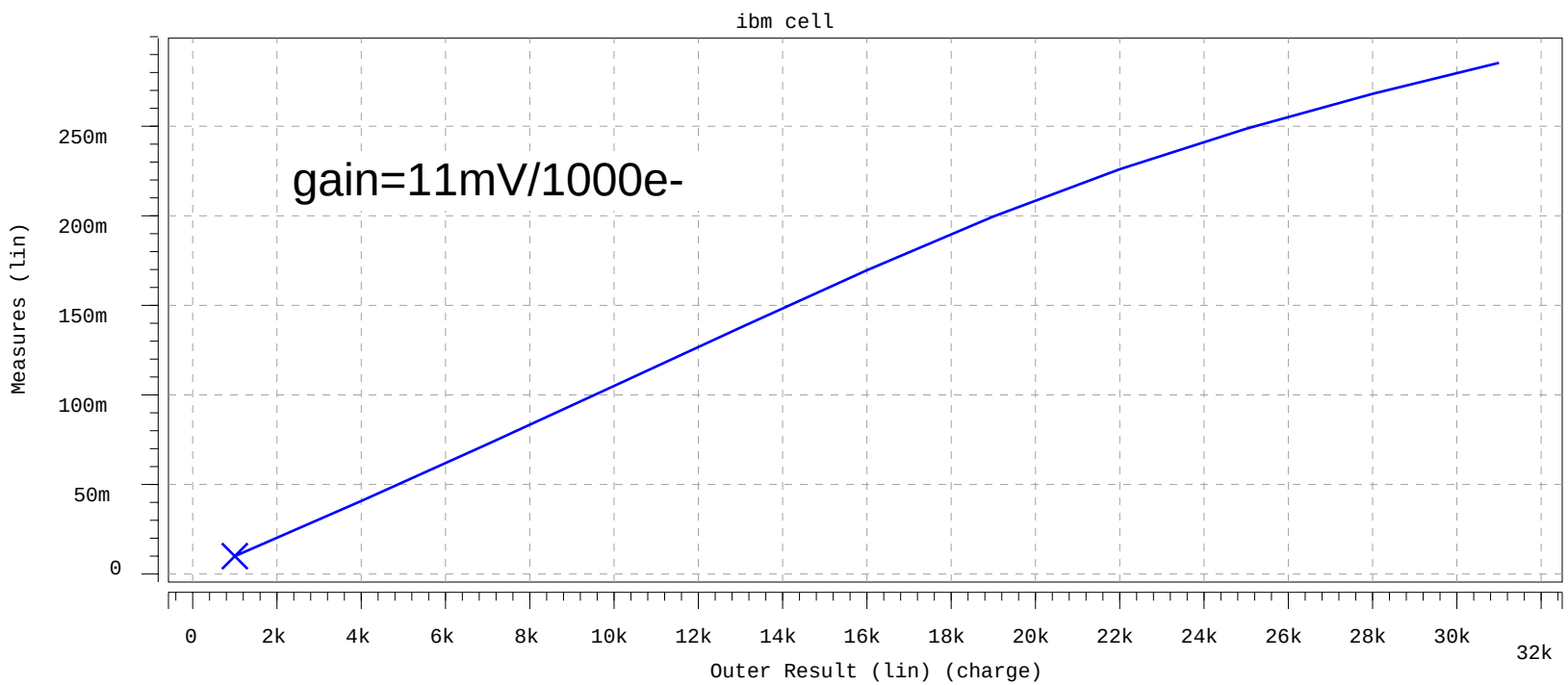

I1
M2
"nch"
l=280n
w=3.31u
w=4u
l=280n
"pch"
M1
VDDD!
VDDD!
out
M0
"nch"
l=280n
w=3.31u
VDDD!
I0b
w=4u
l=280n
"pch"
M6
vddd
gndd
gnd
sel

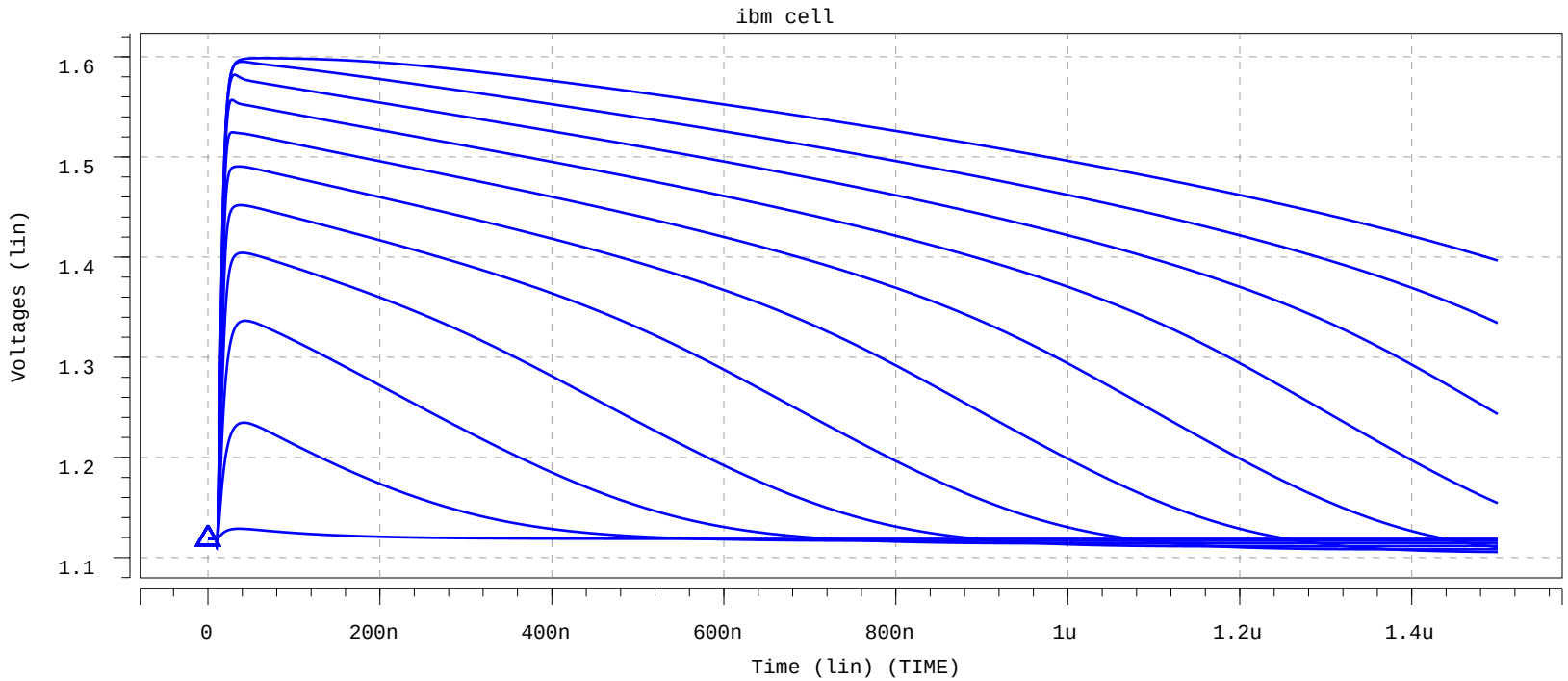
Simulation Results

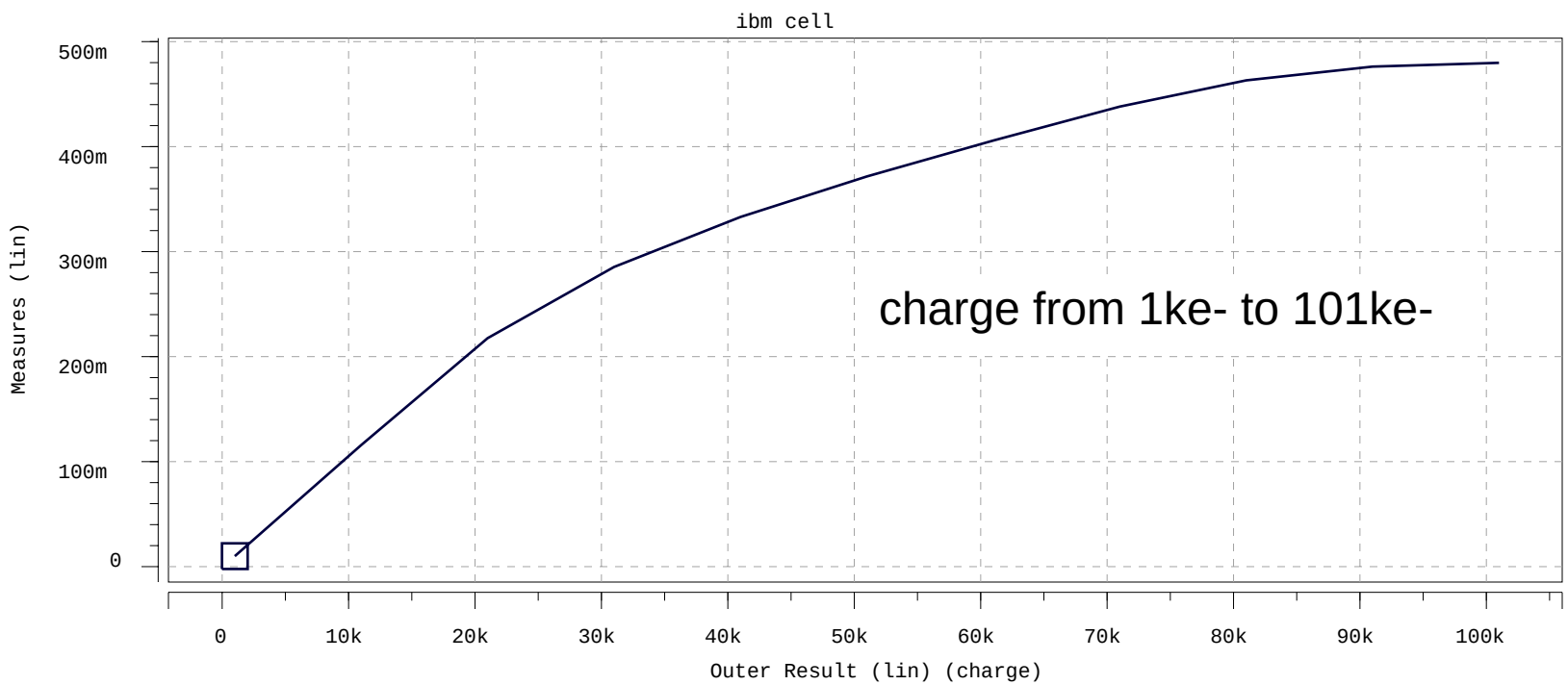

ibm cell
Current Y=6.96e+001
Current X=2.41e+005
Current Y=6.66e+001
OLG=3000
first pole=250kHz
first non dominant pole=149MHz
Gm input Tor = 108uA/V
Volts dB (lin)
60
40
20
0
-20
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)

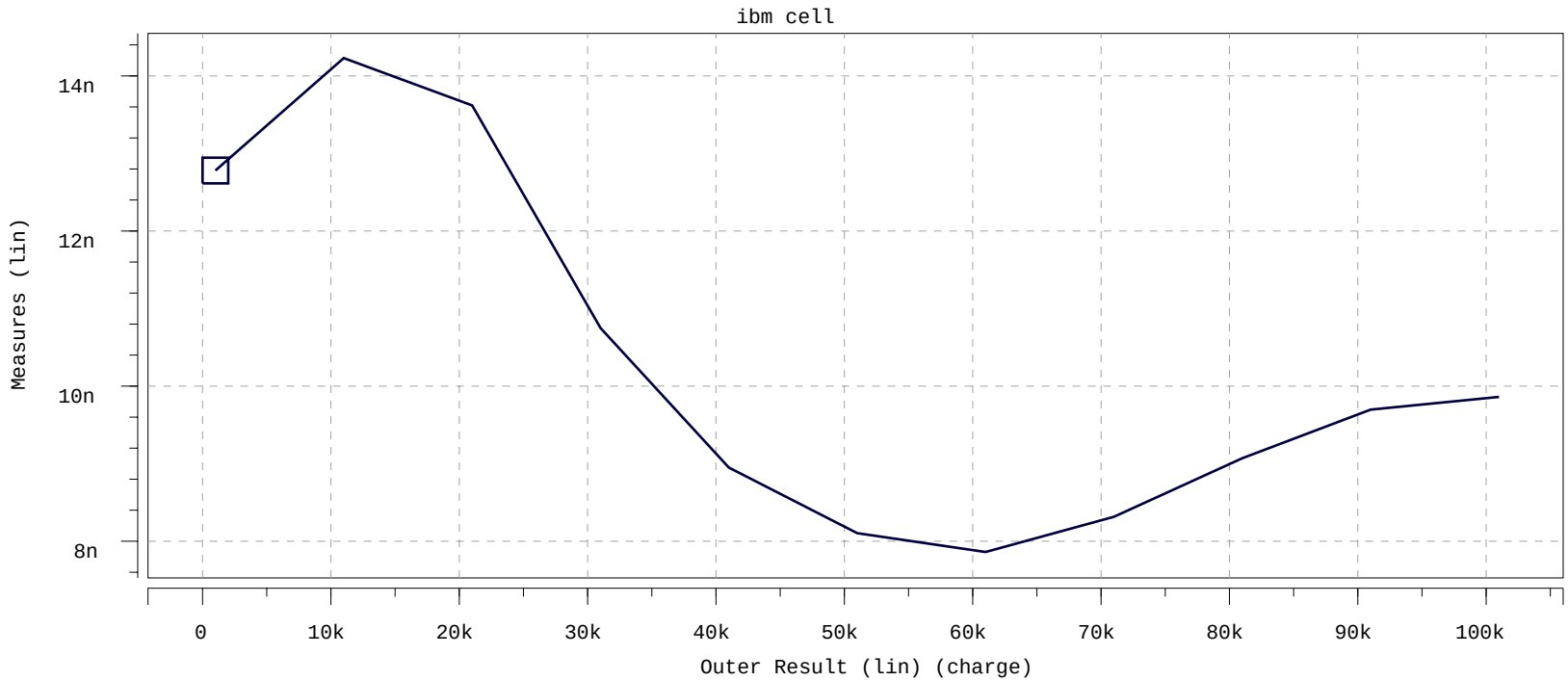

ibm cell
Volts Phase (lin)
150
100
50
0
-50
-100
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)


ibm cell
charge from 1k- to 31ke-
Cdet=400fF, If=3nA
Voltages (lin)
1.4
1.35
1.3
1.25
1.2
1.15
1.1
0
200n
400n
600n
800n
1u
1.2u
1.4u
Time (lin) (TIME)


ibm cell
gain=11mV/1000e-
Measures (lin)
250m
200m
150m
100m
50m
0
0
2k
4k
6k
8k
10k
12k
14k
16k
18k
20k
22k
24k
26k
28k
30k
32k
Outer Result (lin) (charge)

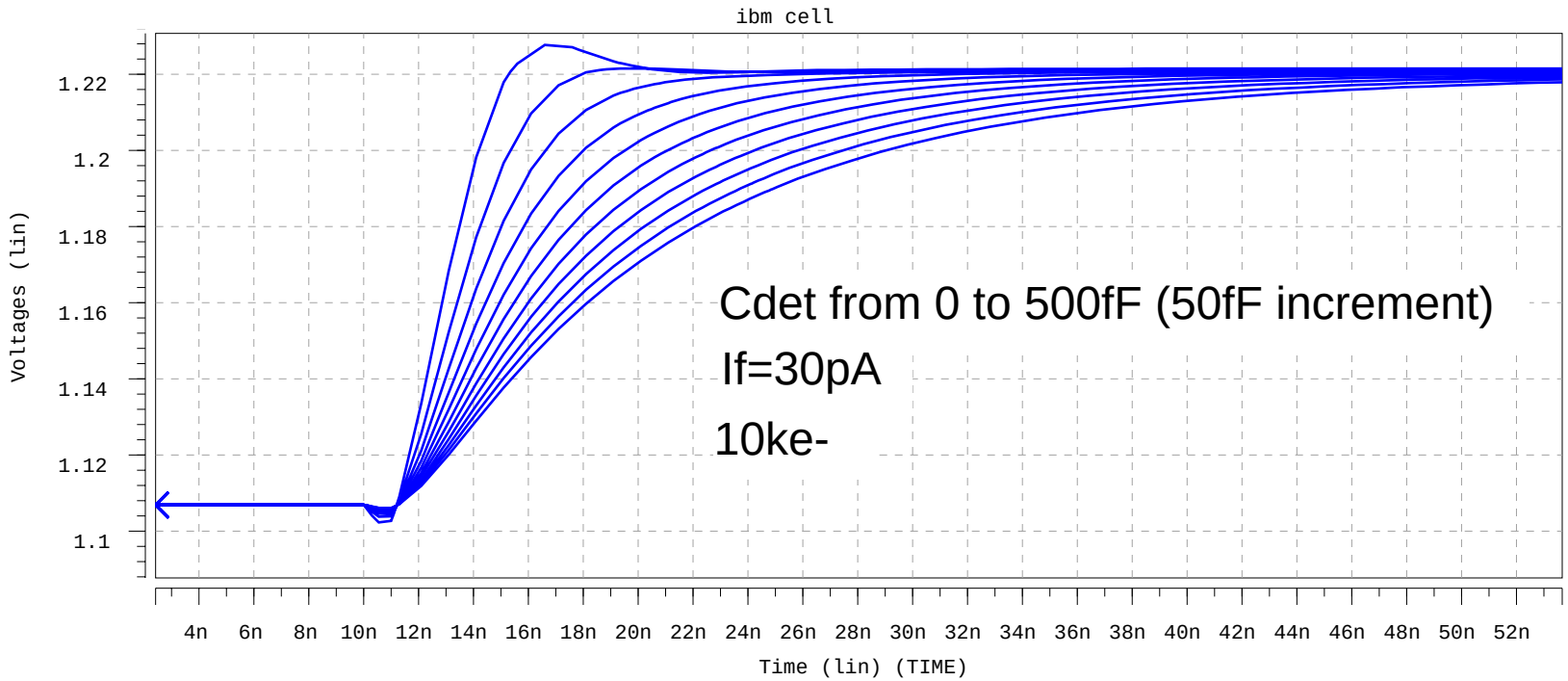

ibm cell
Voltages (lin)
1.6
1.5
1.4
1.3
1.2
1.1
0
200n
400n
600n
800n
1u
1.2u
1.4u
Time (lin) (TIME)

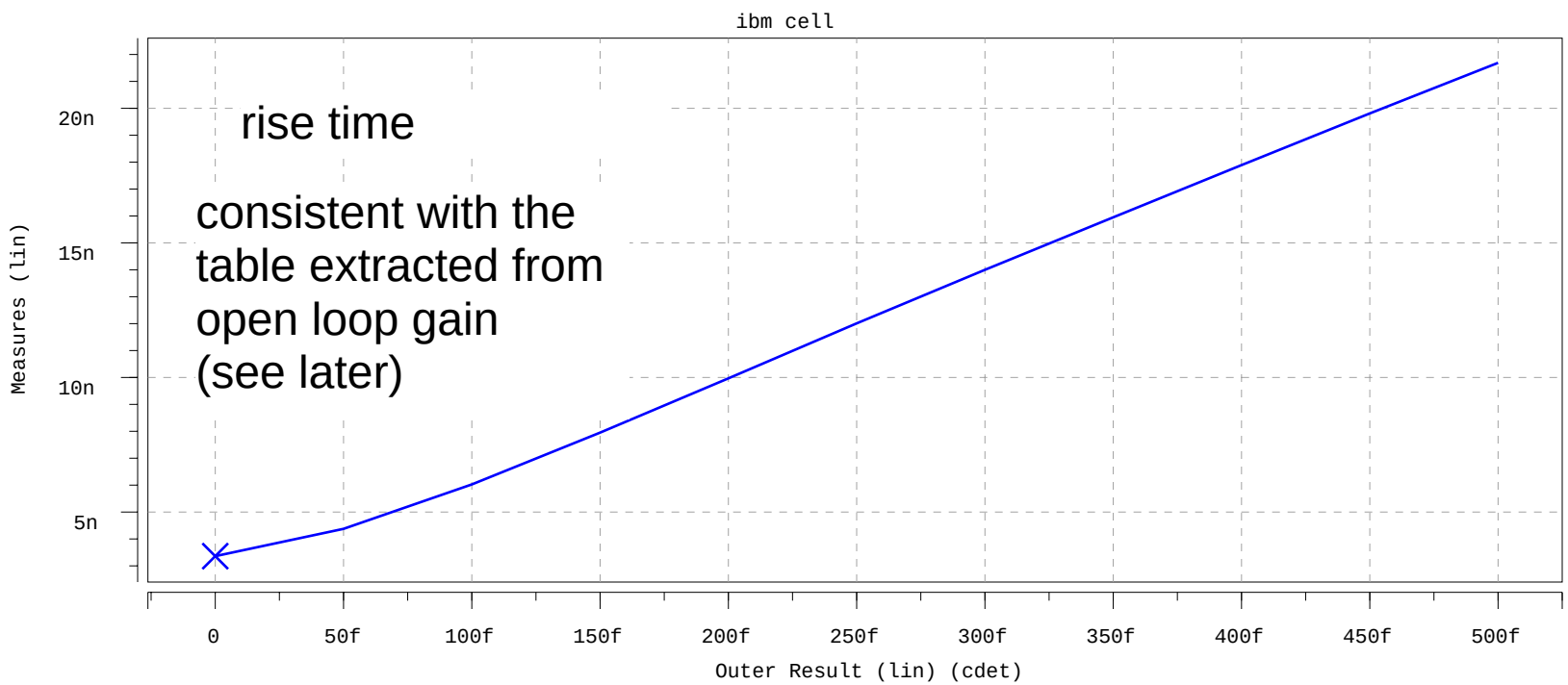

ibm cell
Measures (lin)
500m
400m
300m
200m
100m
0
charge from 1ke- to 101ke-
0
10k
20k
30k
40k
50k
60k
70k
80k
90k
100k
Outer Result (lin) (charge)

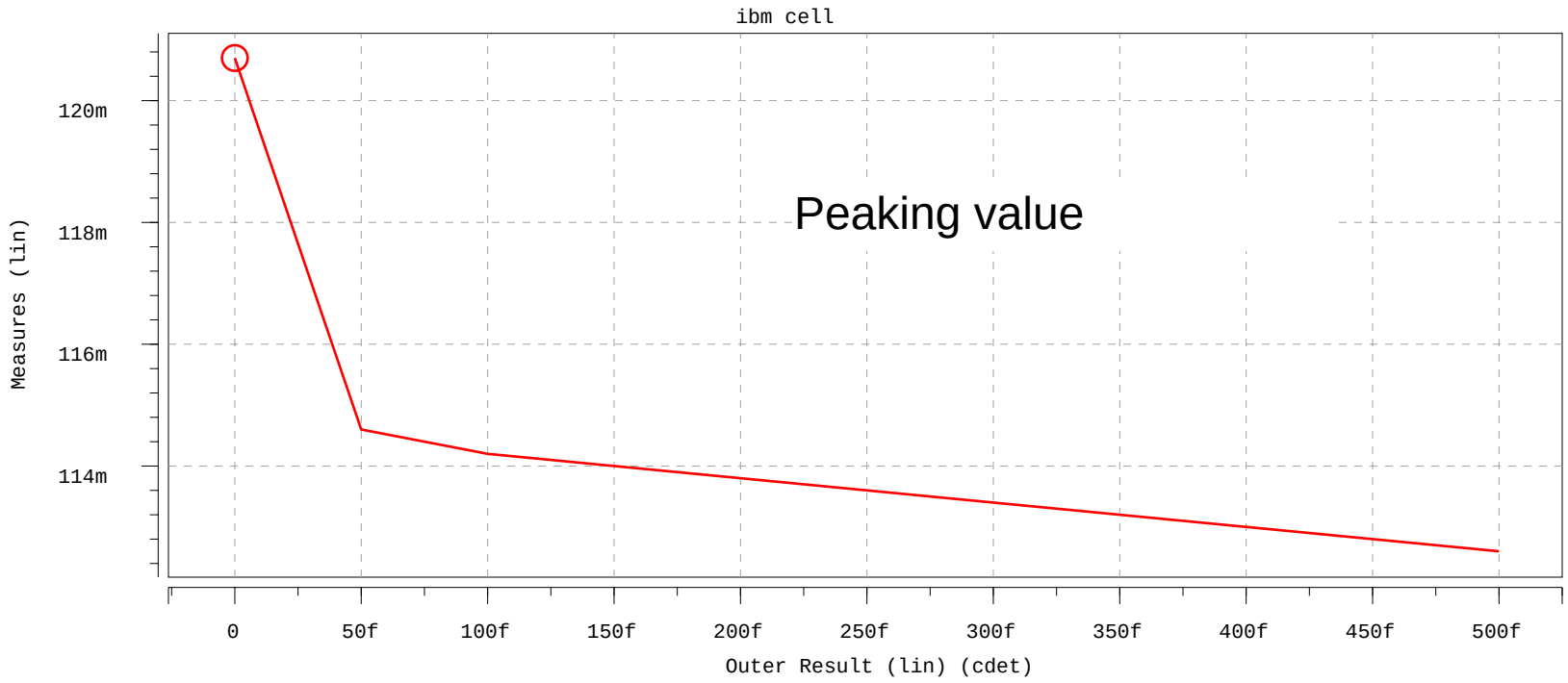


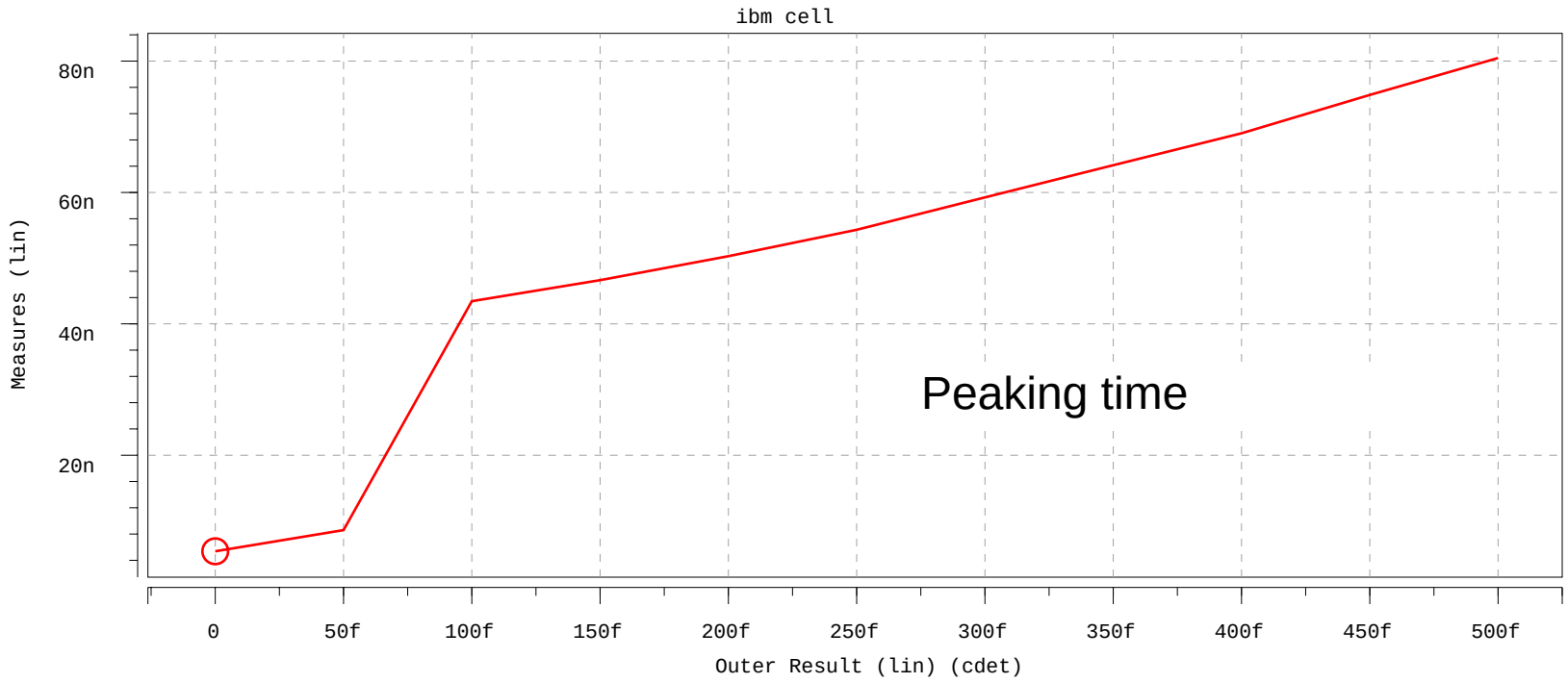
DC LEVEL

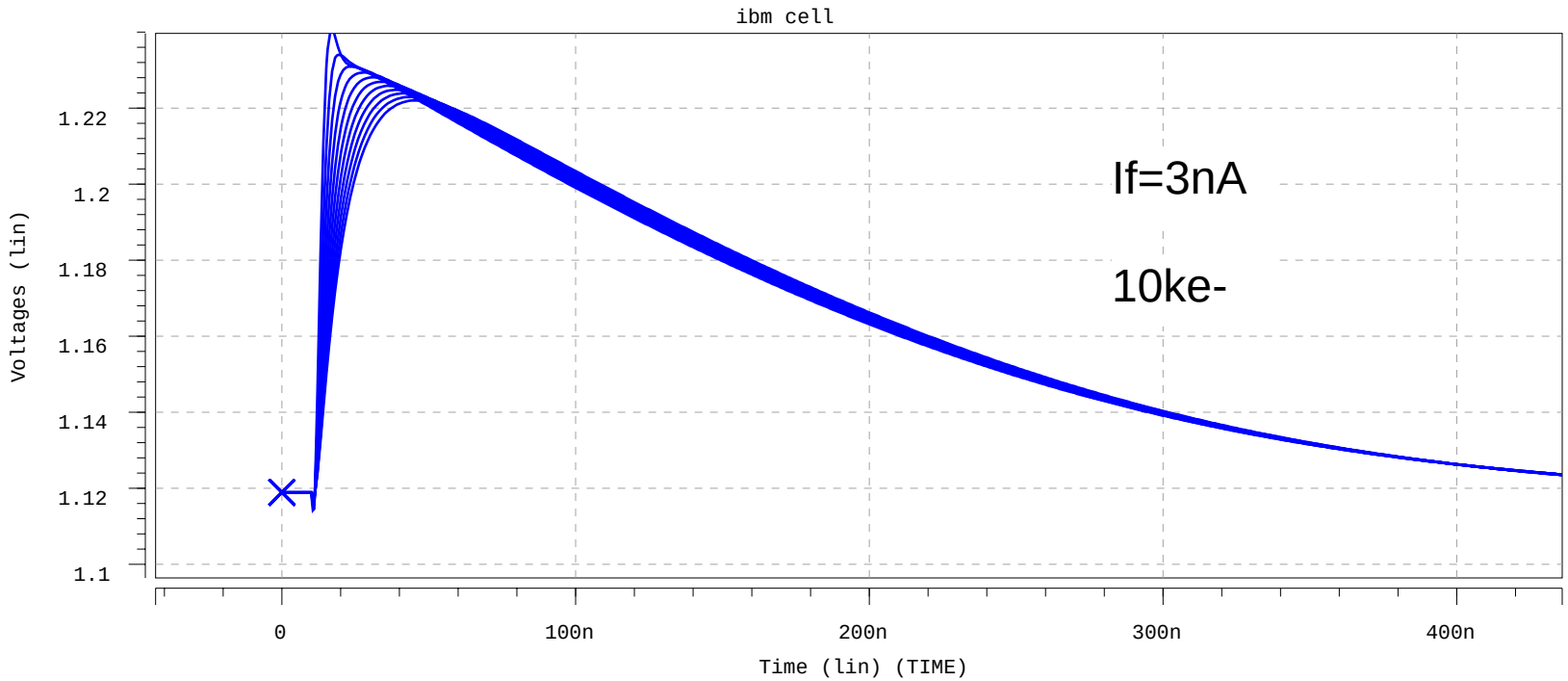
idisc = 885.9232m if = 313.8621m il = 706.8171m il2 = 622.6964m
ip = 684.3992m ip2 = 851.6837m isui = 562.8955m ith = 537.0542m
ivdd2 = 495.0290m
in =1.0368 ina = 461.1347m inb = 480.7910m
out1 =1.1189 out2a = 611.6471m out2b = 438.5009m
outdisb = 649.3152m outleak = 1.1444 sour2 = 1.0427
sourdis = 1.0683 v1 = 1.0297 v3 = 460.7145m
vcasc = 412.7314m vcomp = 641.4577m vcopy1 = 659.8074m
vcopy2 = 1.1202 vdd2 = 1.1444 vif = 659.9670m
vif2 = 1.2224

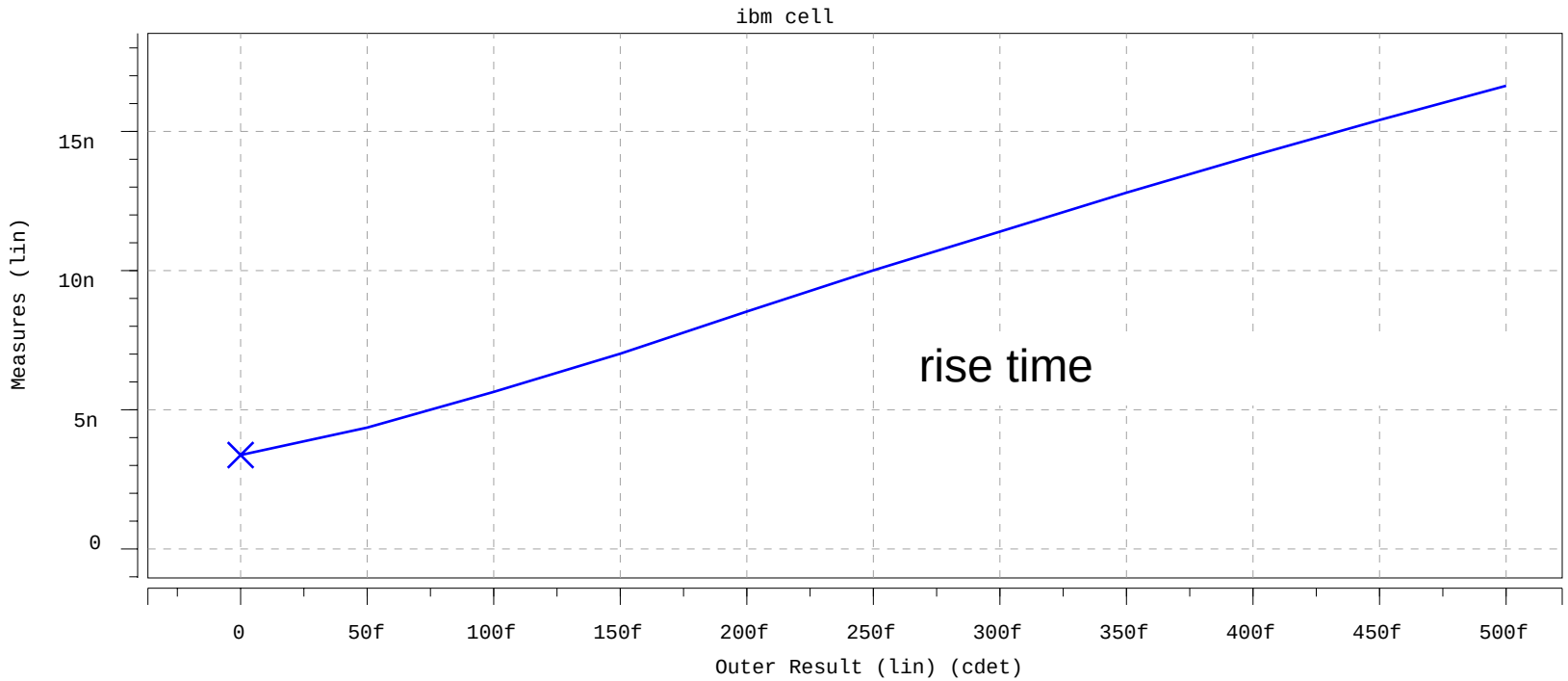

ibm cell
Voltages (lin)
1.22
1.2
1.18
1.16
1.14
1.12
1.1
Cdet from 0 to 500fF (50fF increment)
If=30pA
10ke-
4n 6n 8n 10n 12n 14n 16n 18n 20n 22n 24n 26n 28n 30n 32n 34n 36n 38n 40n 42n 44n 46n 48n 50n 52n
Time (lin) (TIME)

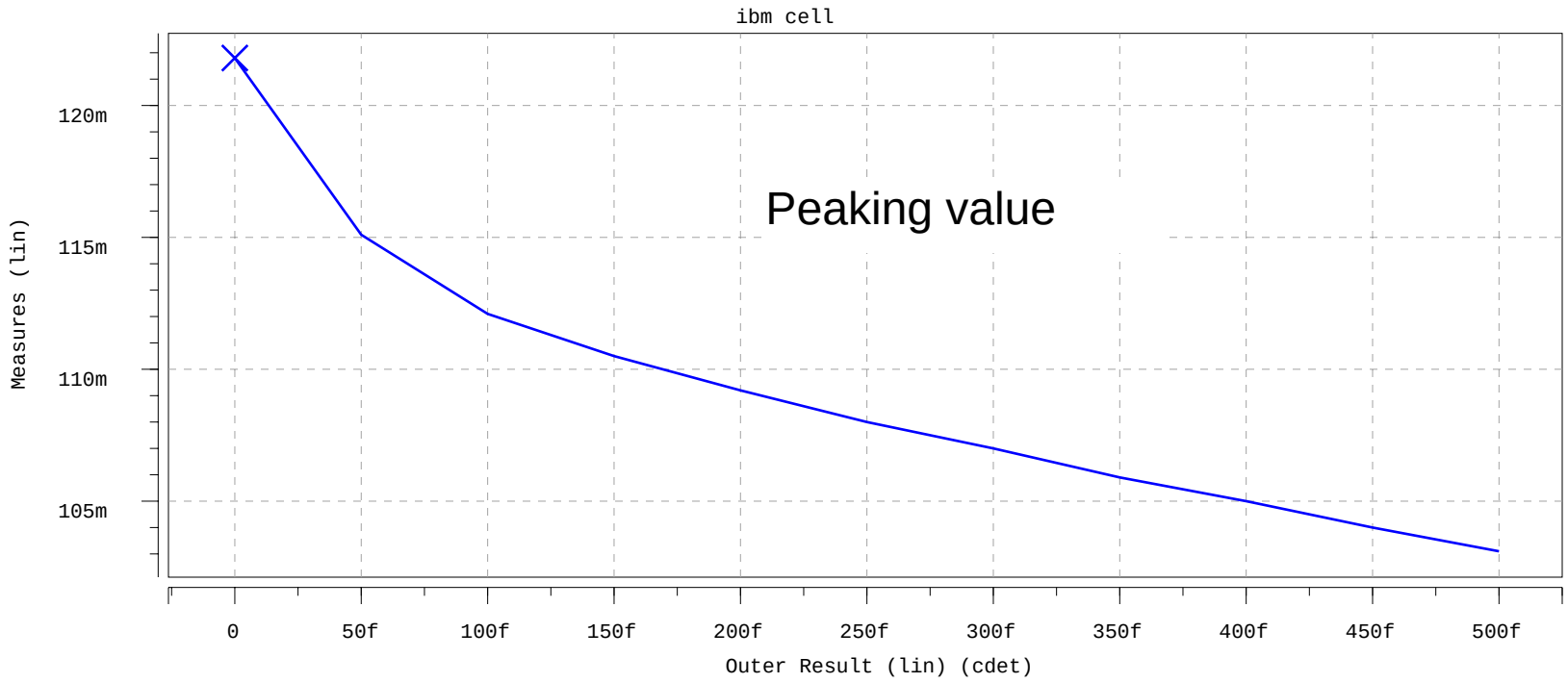

ibm cell
Measures (lin)
20n
15n
10n
5n
rise time
consistent with the
table extracted from
open loop gain
(see later)
0 50f 100f 150f 200f 250f 300f 350f 400f 450f 500f
Outer Result (lin) (cdet)

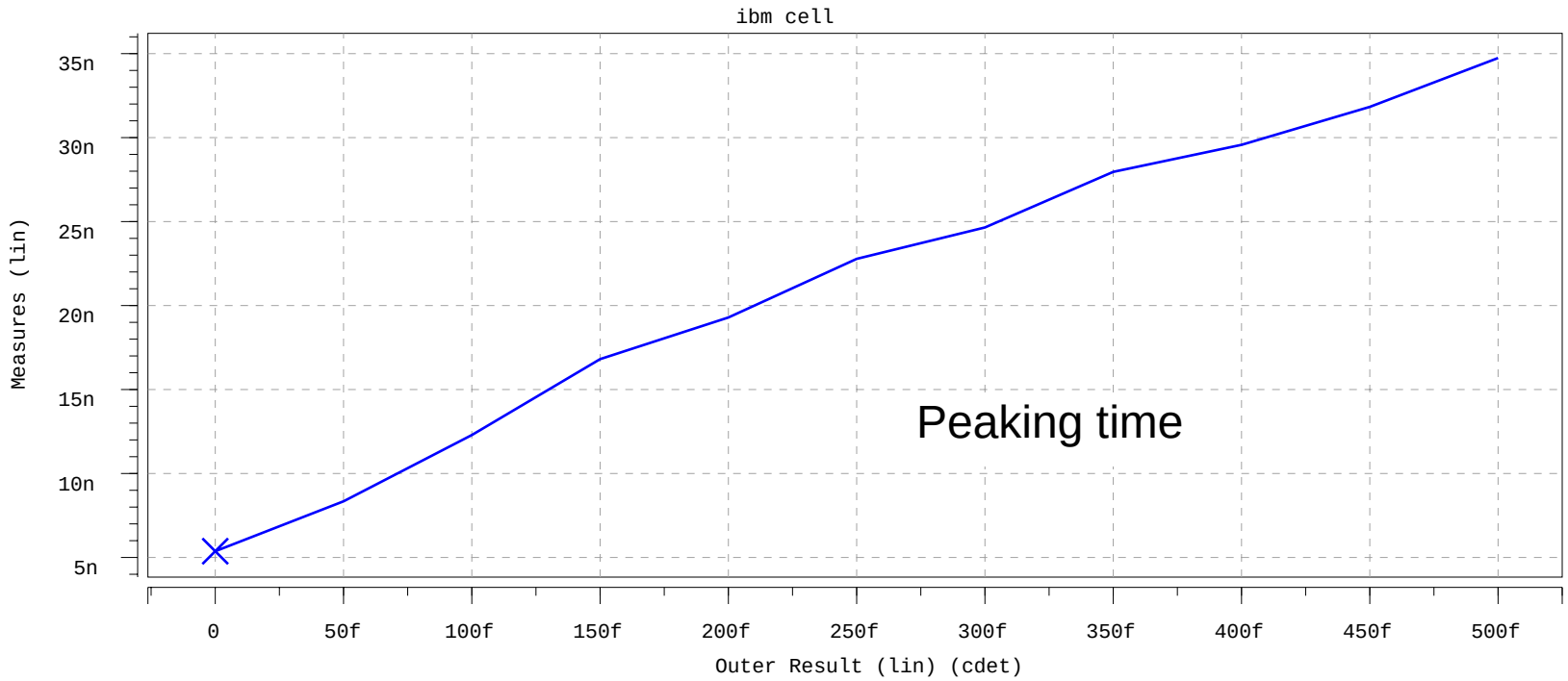

ibm cell
Peaking value
Measures (lin)
120m
118m
116m
114m
0
50f
100f
150f
200f
250f
300f
350f
400f
450f
500f
Outer Result (lin) (cdet)

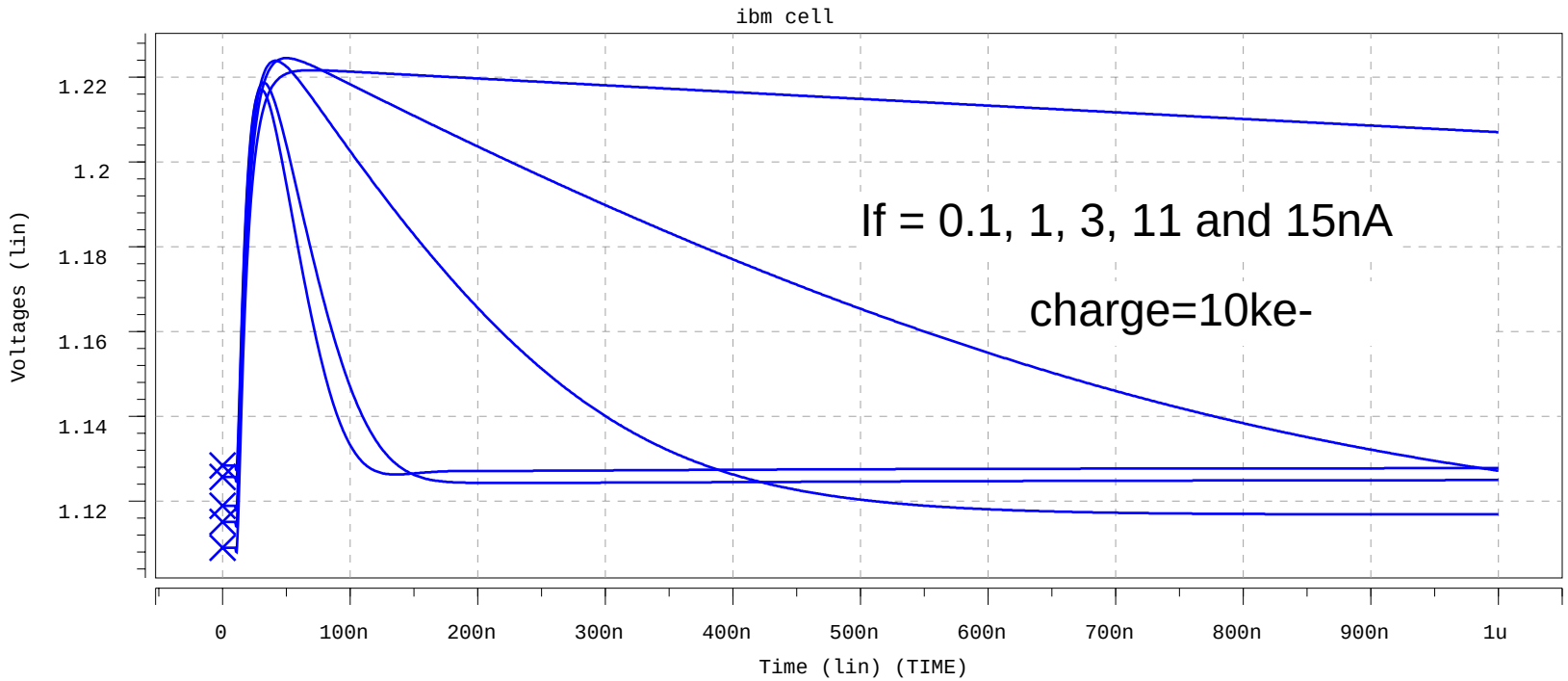

ibm cell
Peaking time
Measures (lin)
80n
60n
40n
20n
0
50f
100f
150f
200f
250f
300f
350f
400f
450f
500f
Outer Result (lin) (cdet)

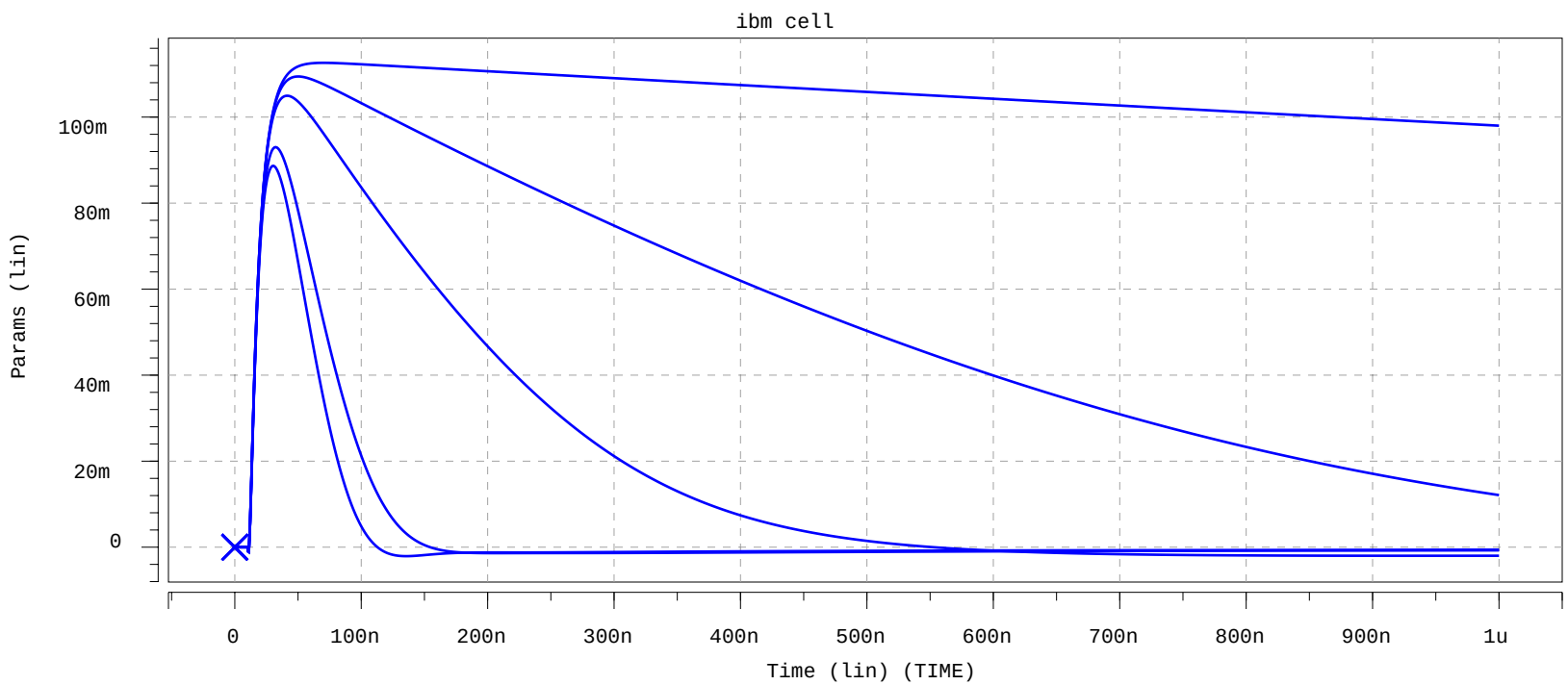

ibm cell
If=3nA
10ke-
Voltages (lin)
1.22
1.2
1.18
1.16
1.14
1.12
1.1
0
100n
200n
300n
400n
Time (lin) (TIME)

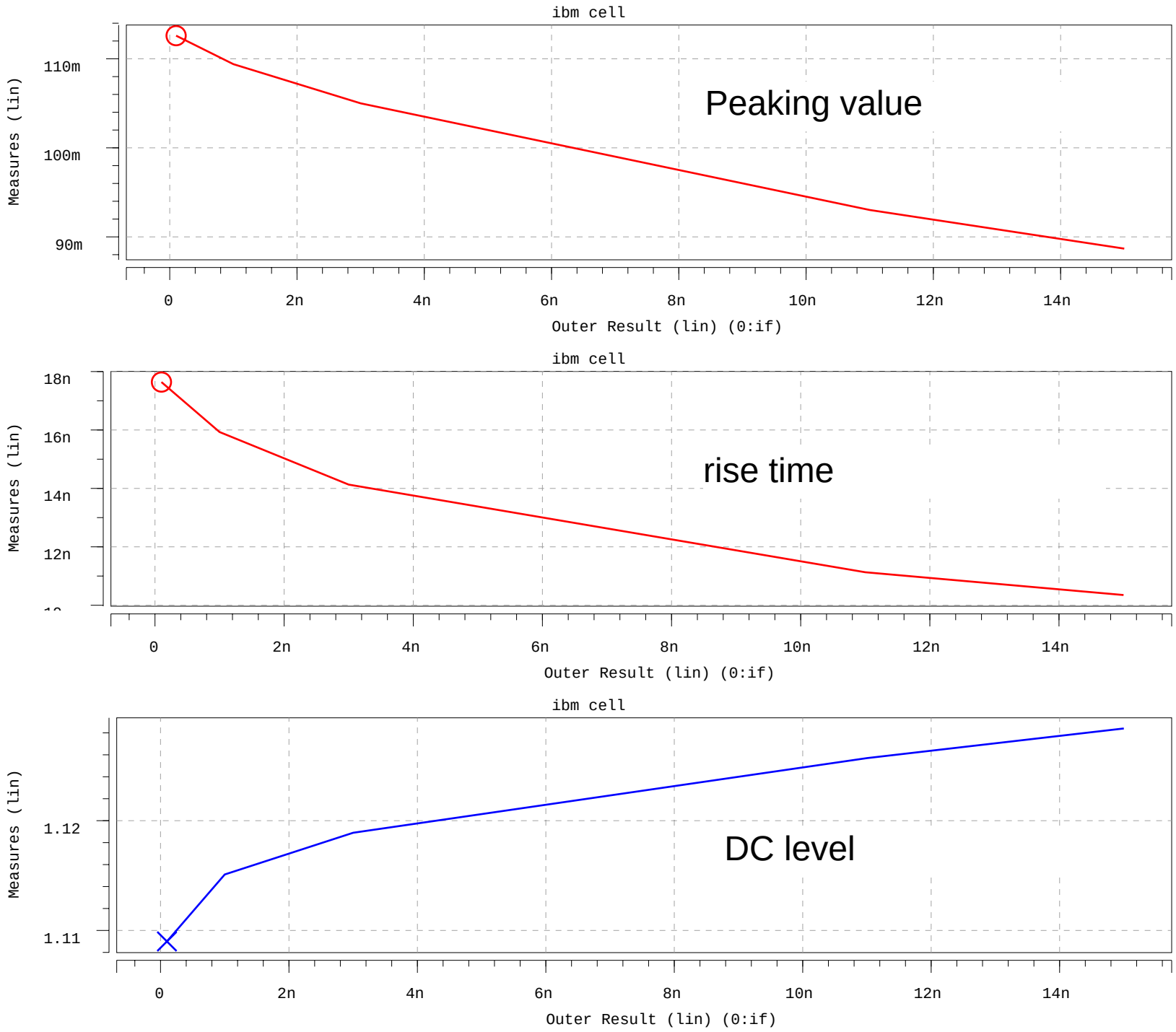

ibm cell
rise time
Measures (lin)
15n
10n
5n
0
0
50f
100f
150f
200f
250f
300f
350f
400f
450f
500f
Outer Result (lin) (cdet)

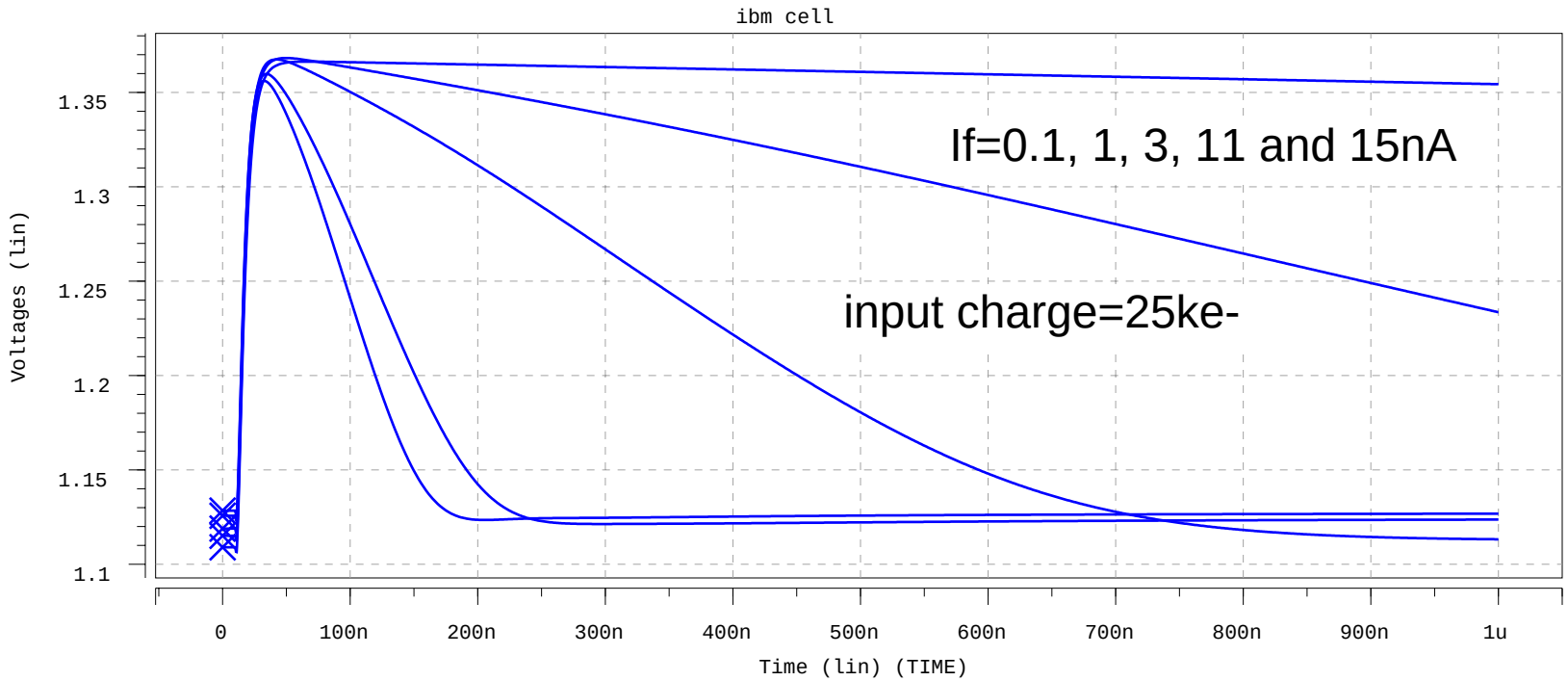

ibm cell
Peaking value
Measures (lin)
120m
115m
110m
105m
0
50f
100f
150f
200f
250f
300f
350f
400f
450f
500f
Outer Result (lin) (cdet)

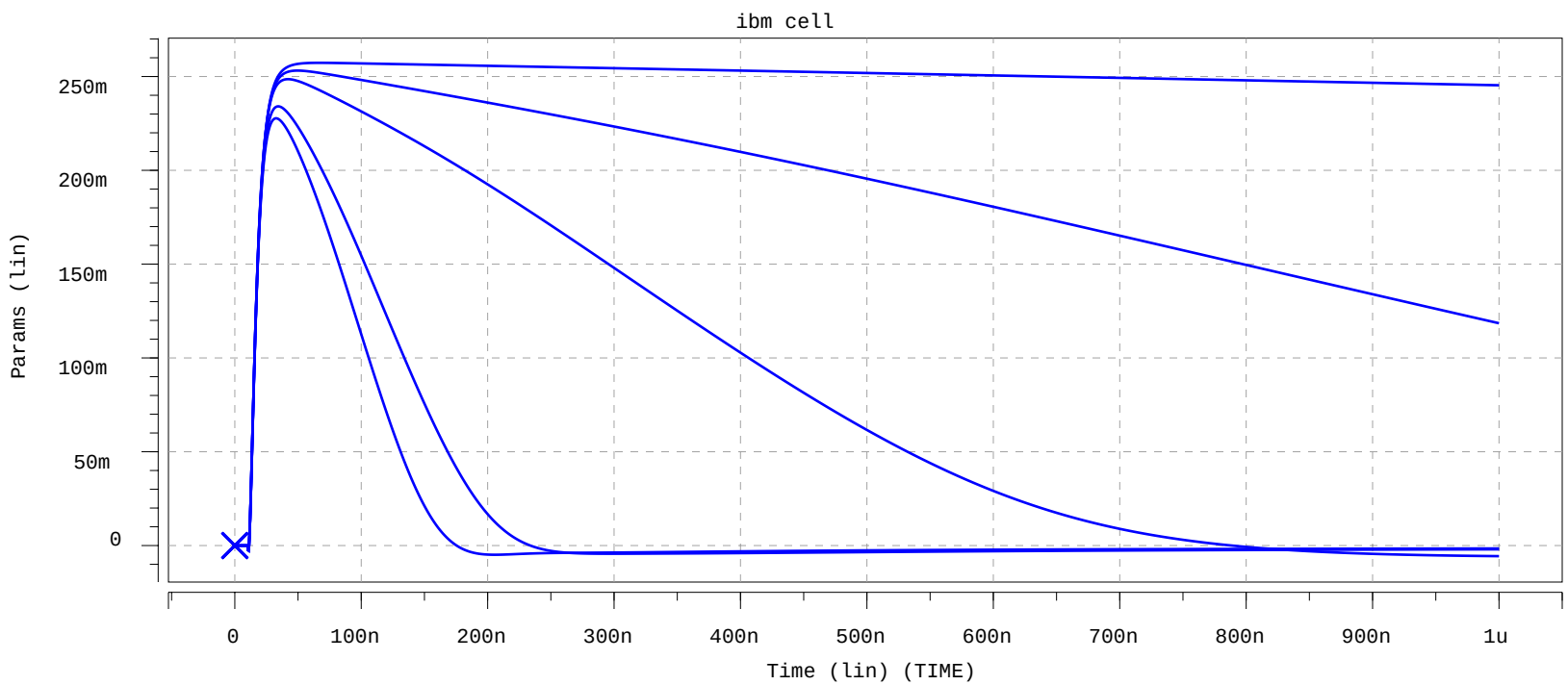

ibm cell
Peaking time
Measures (lin)
35n
30n
25n
20n
15n
10n
5n
0
50f
100f
150f
200f
250f
300f
350f
400f
450f
500f
Outer Result (lin) (cdet)

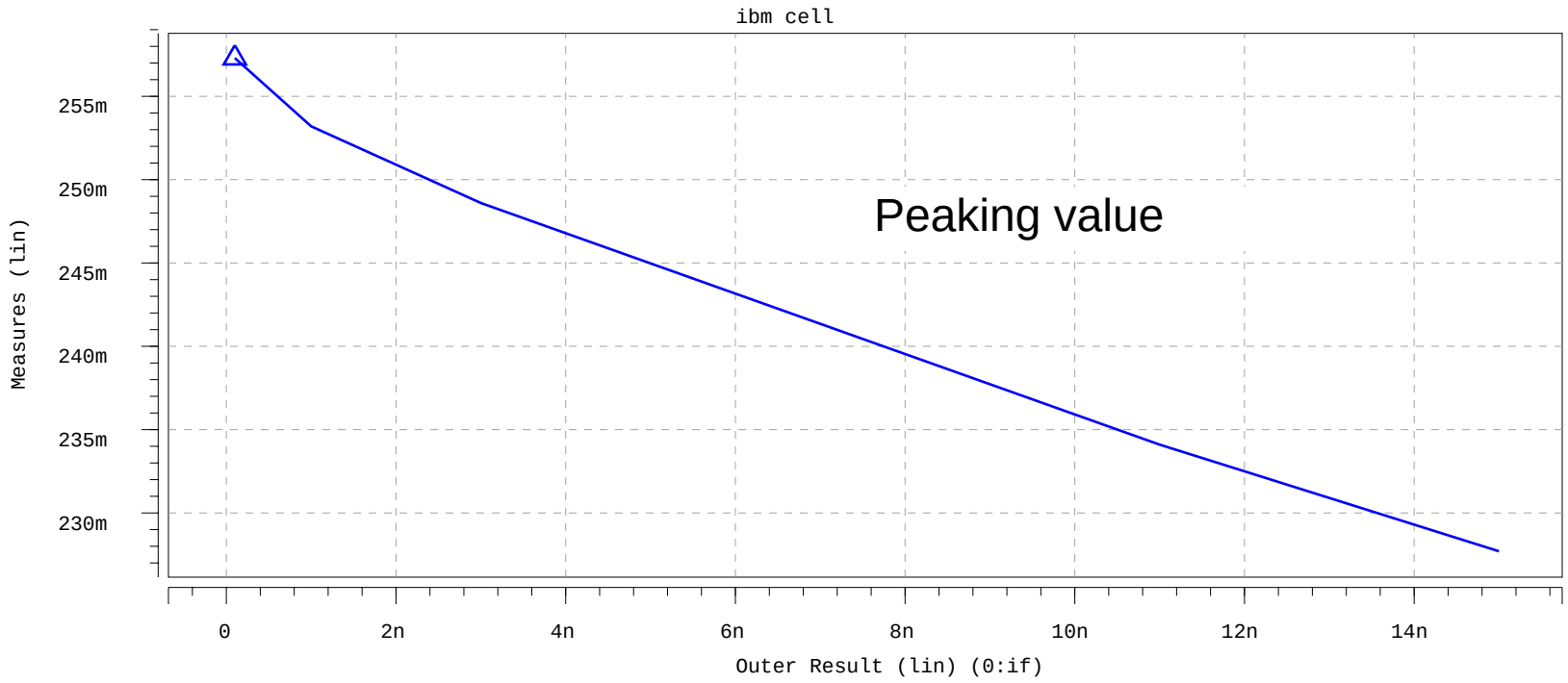

ibm cell
Voltages (lin)
1.22
1.2
1.18
1.16
1.14
1.12
If = 0.1, 1, 3, 11 and 15nA
charge=10ke-
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

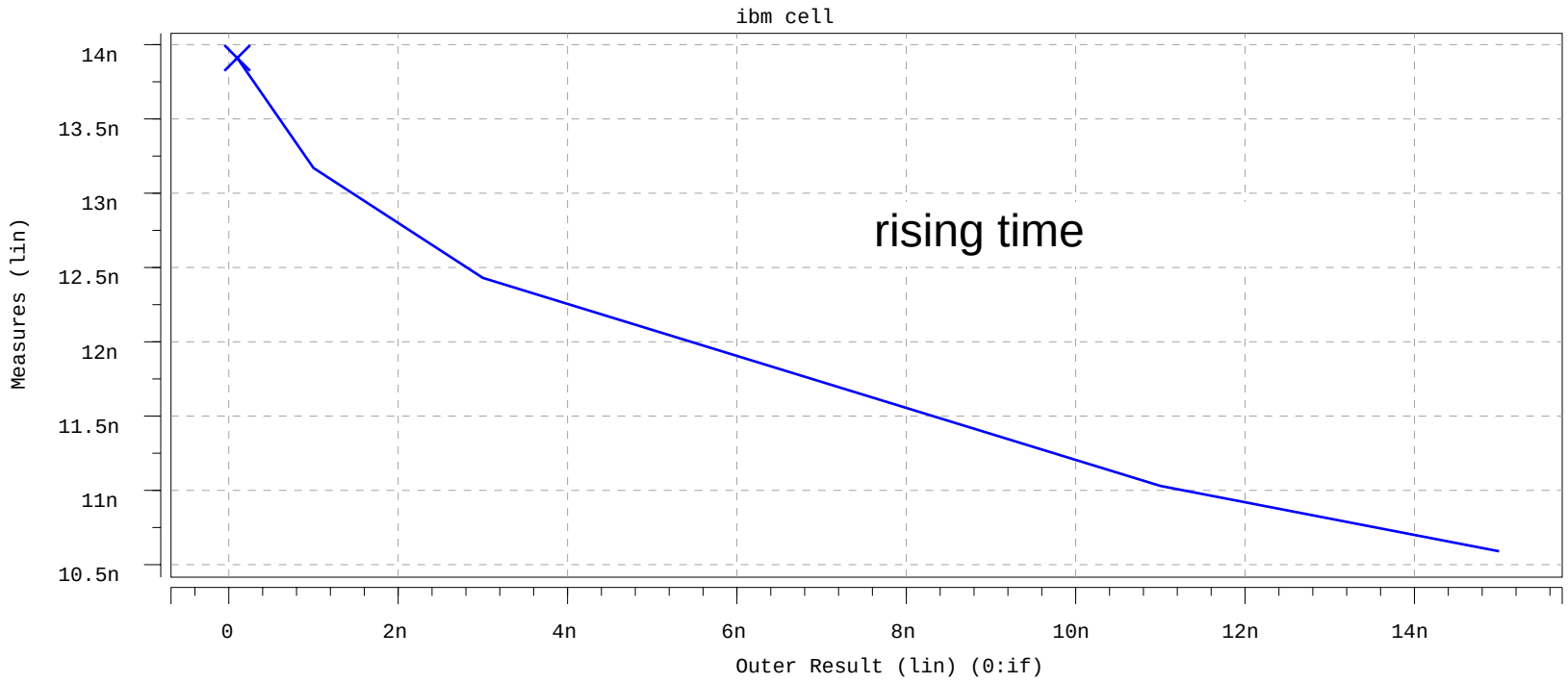

ibm cell
Params (lin)
100m
80m
60m
40m
20m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

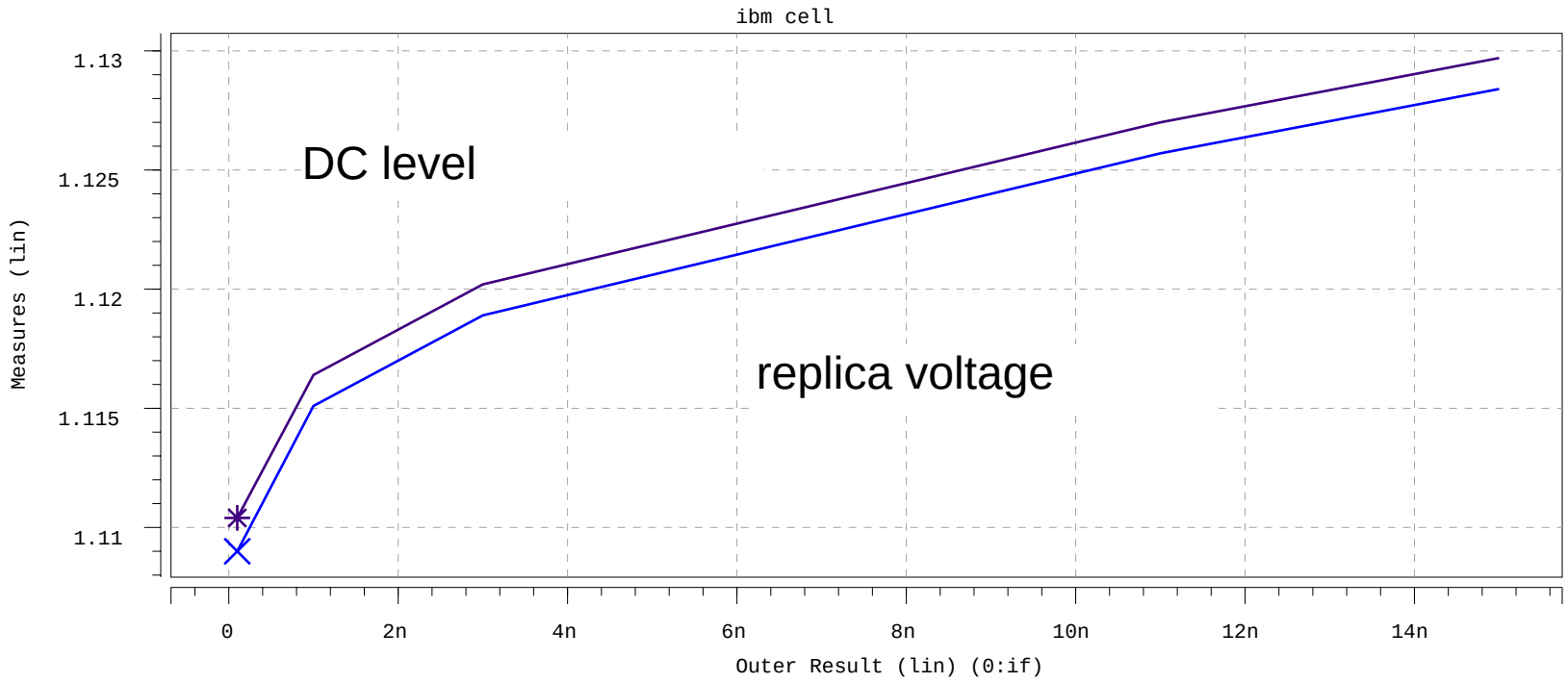

ibm cell
Peaking value
Measures (lin)
110m
100m
90m
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)
ibm cell
rise time
Measures (lin)
18n
16n
14n
12n
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)
ibm cell
DC level
Measures (lin)
1.12
1.11
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)

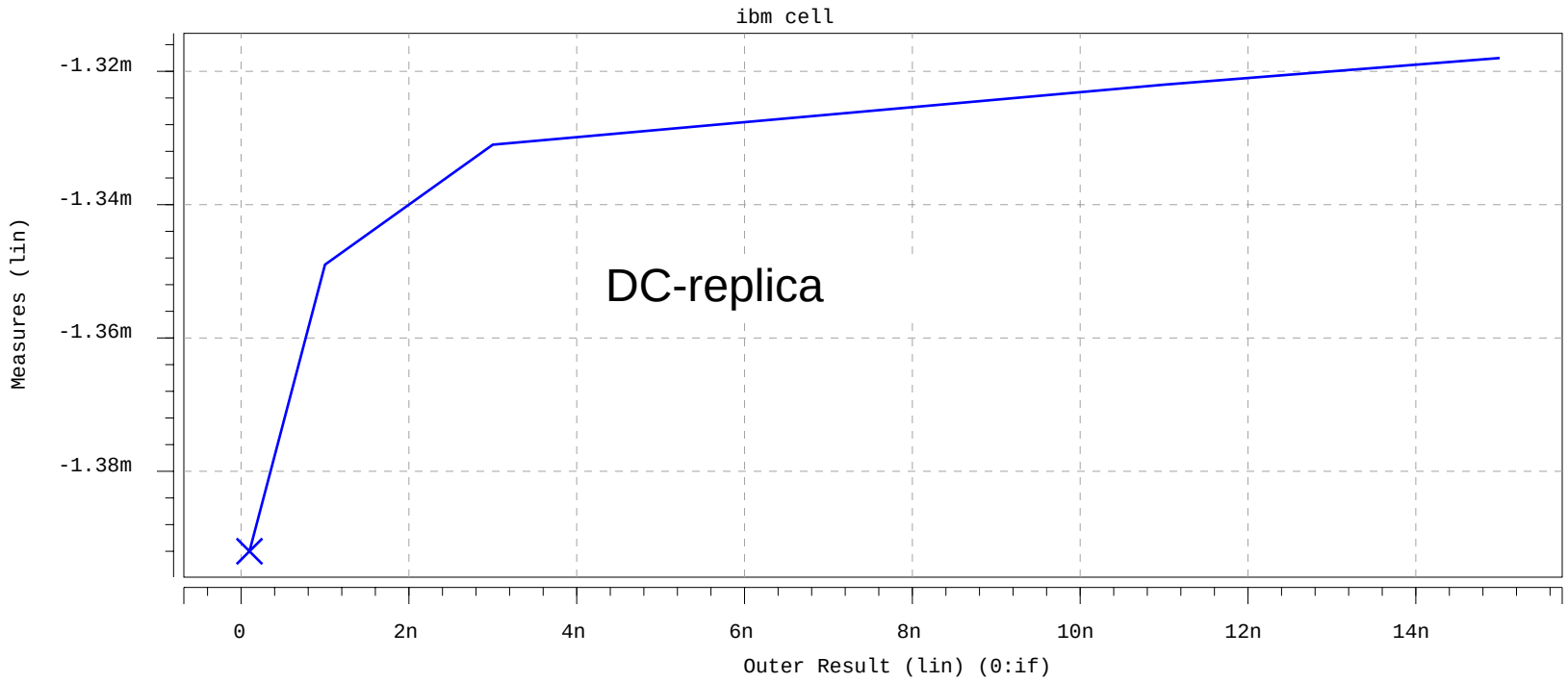

ibm cell
If=0.1, 1, 3, 11 and 15nA
input charge=25ke-
Voltages (lin)
1.35
1.3
1.25
1.2
1.15
1.1
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

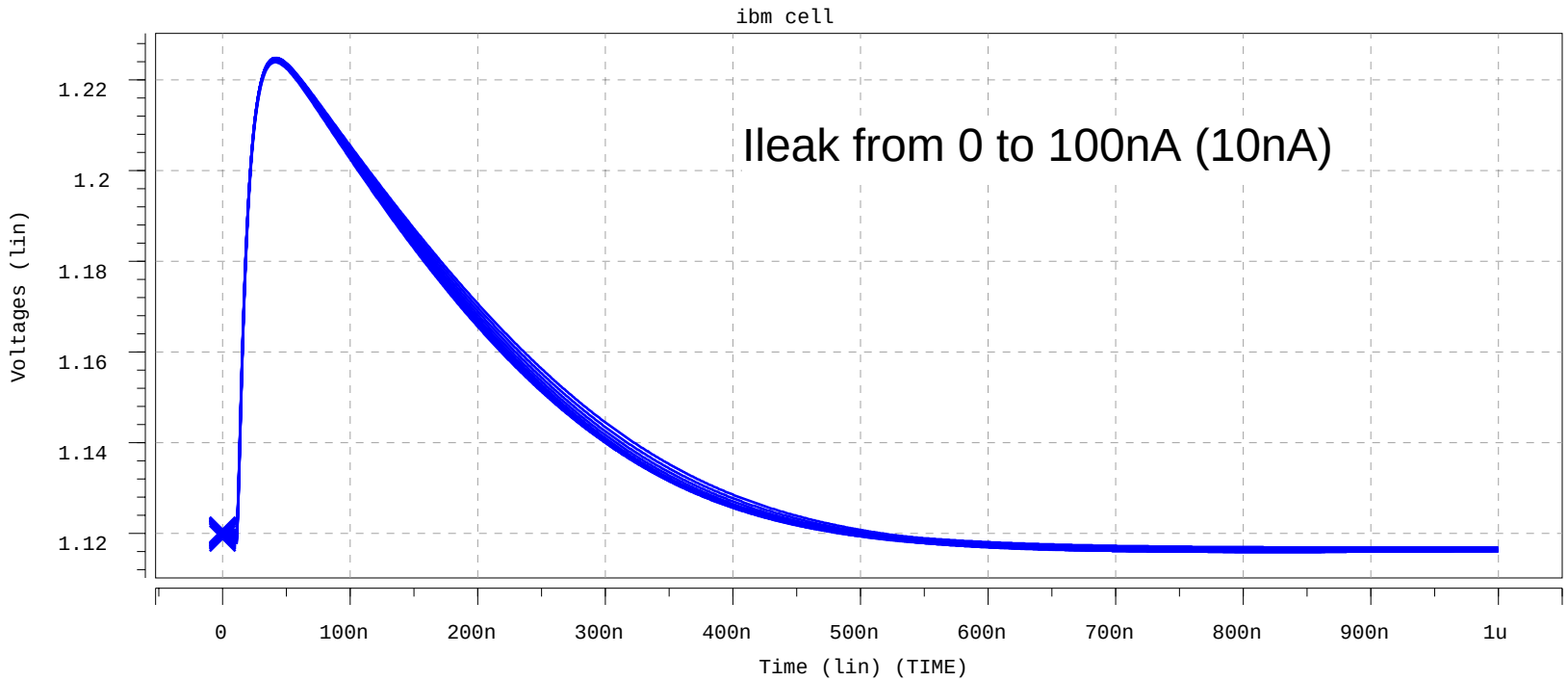

ibm cell
Params (lin)
250m
200m
150m
100m
50m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

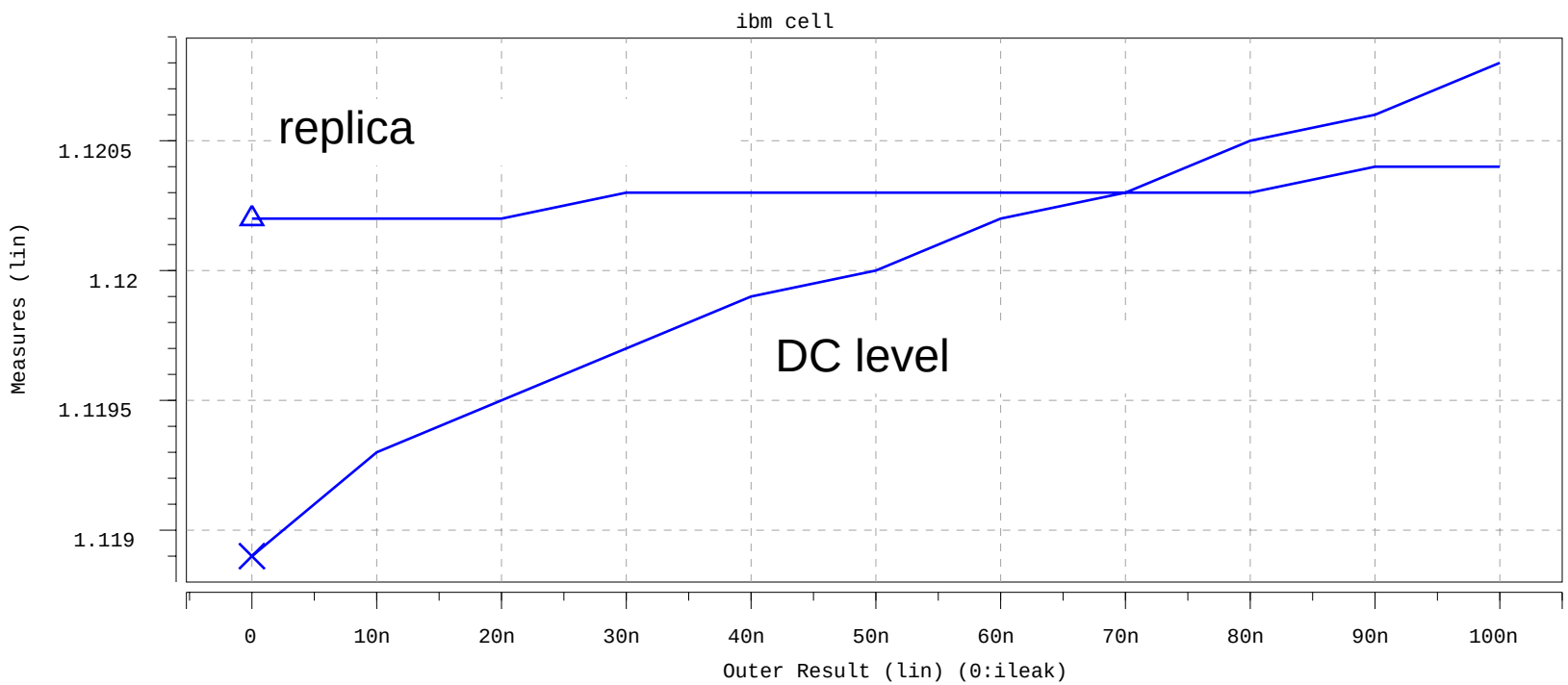

ibm cell
Peaking value
Measures (lin)
255m
250m
245m
240m
235m
230m
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)

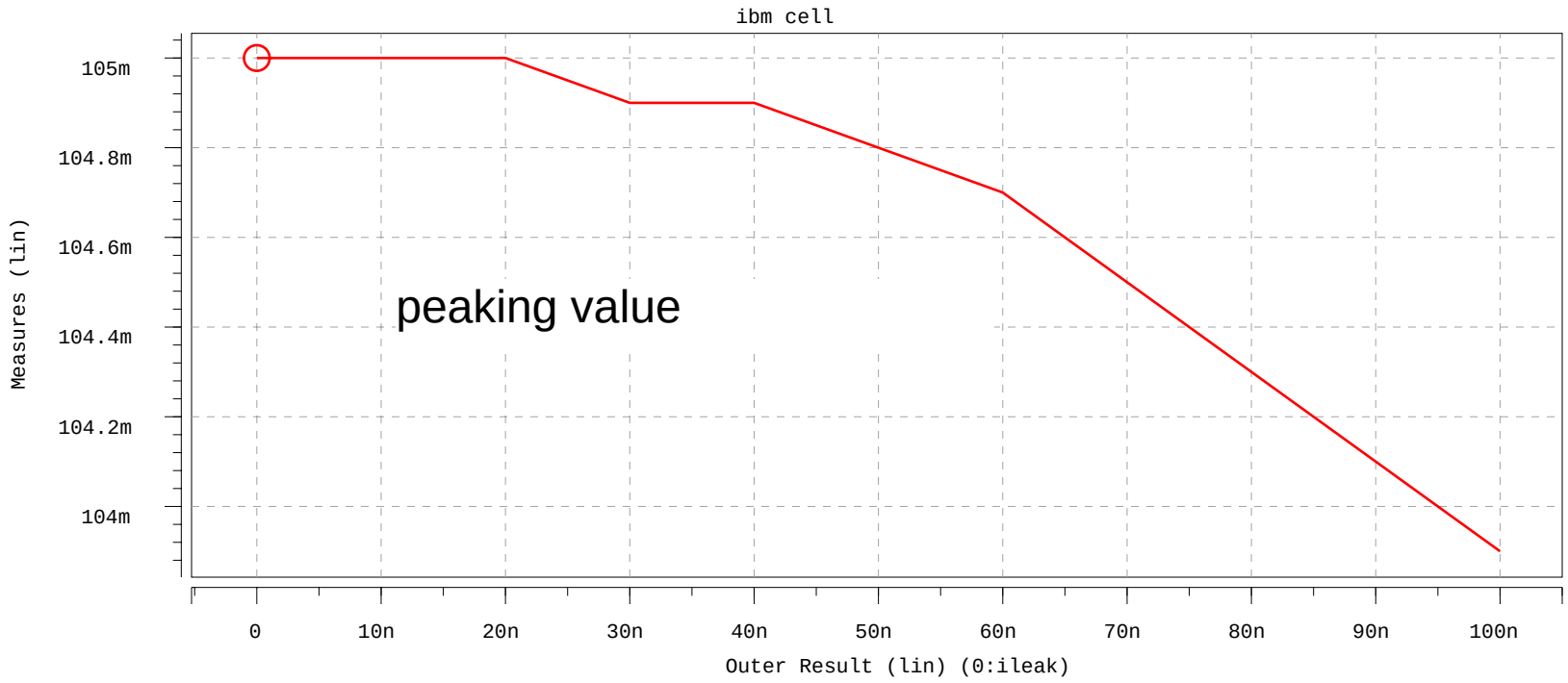

ibm cell
rising time
Measures (lin)
14n
13.5n
13n
12.5n
12n
11.5n
11n
10.5n
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)

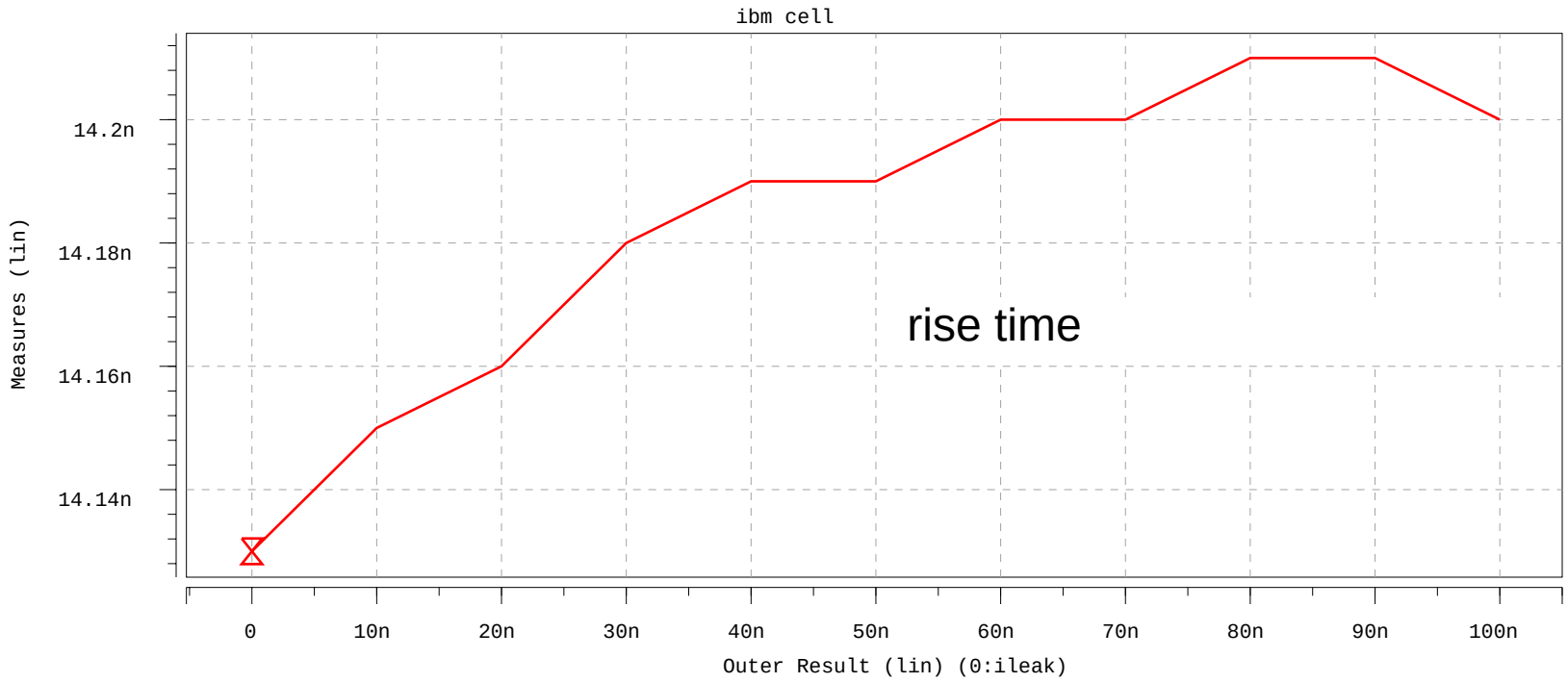

ibm cell
DC level
replica voltage
Measures (lin)
1.13
1.125
1.12
1.115
1.11
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)

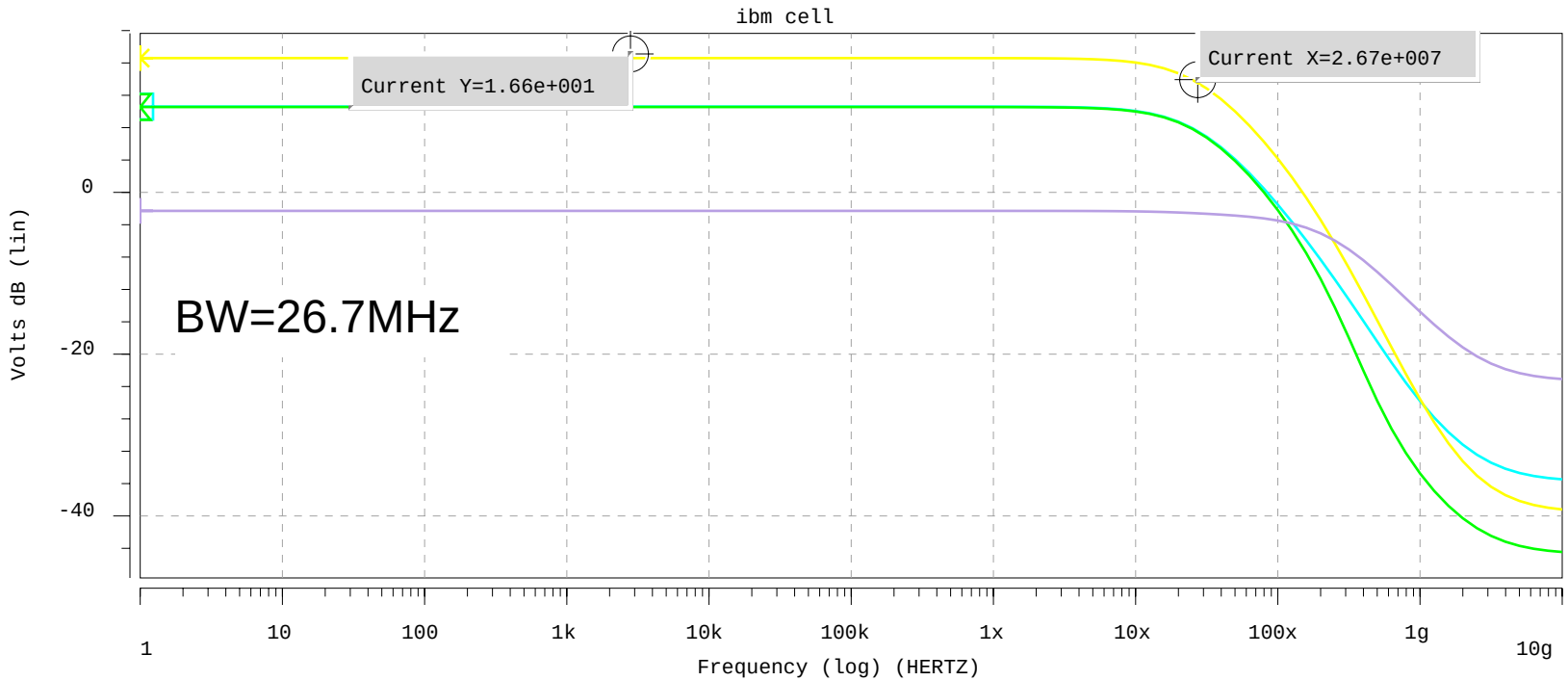

ibm cell
DC-replica
Measures (lin)
-1.32m
-1.34m
-1.36m
-1.38m
0
2n
4n
6n
8n
10n
12n
14n
Outer Result (lin) (0:if)

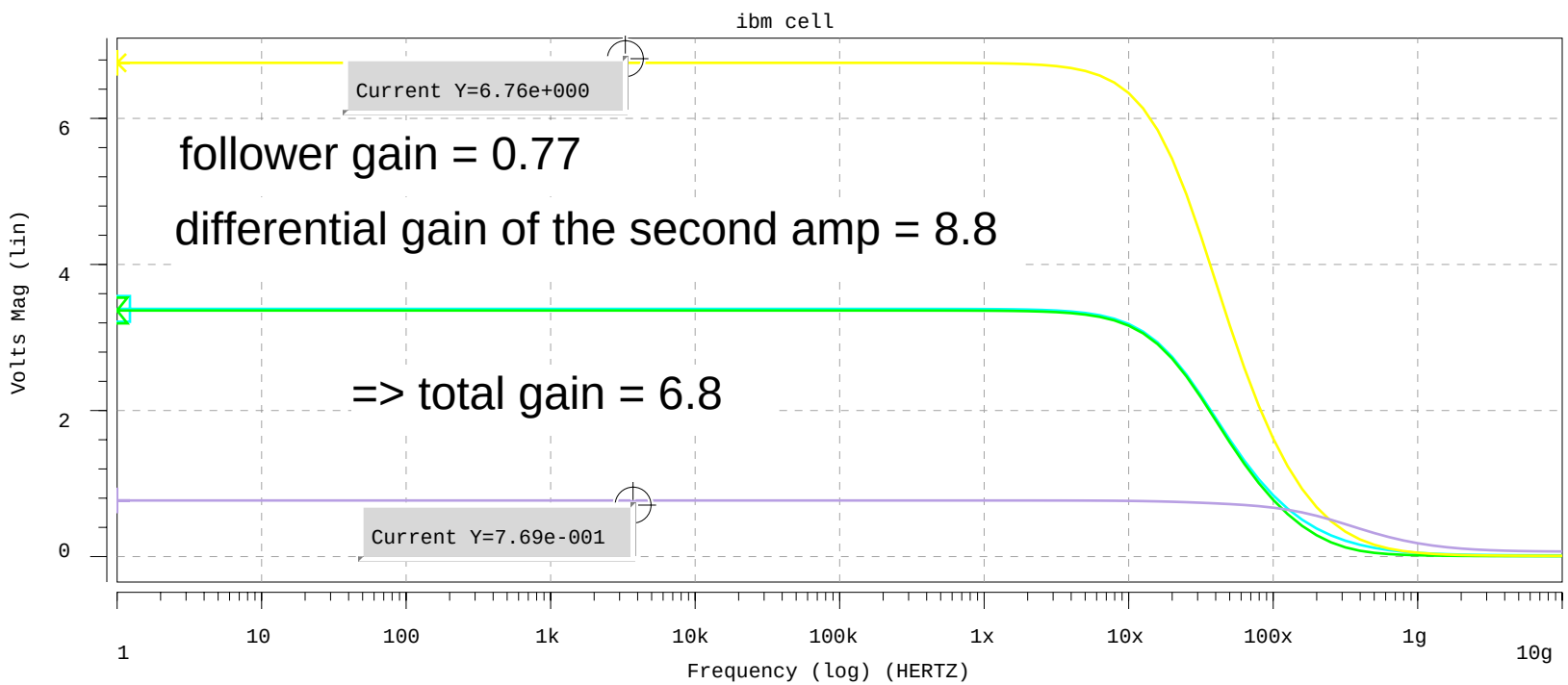

ibm cell
Ileak from 0 to 100nA (10nA)
Voltages (lin)
1.22
1.2
1.18
1.16
1.14
1.12
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

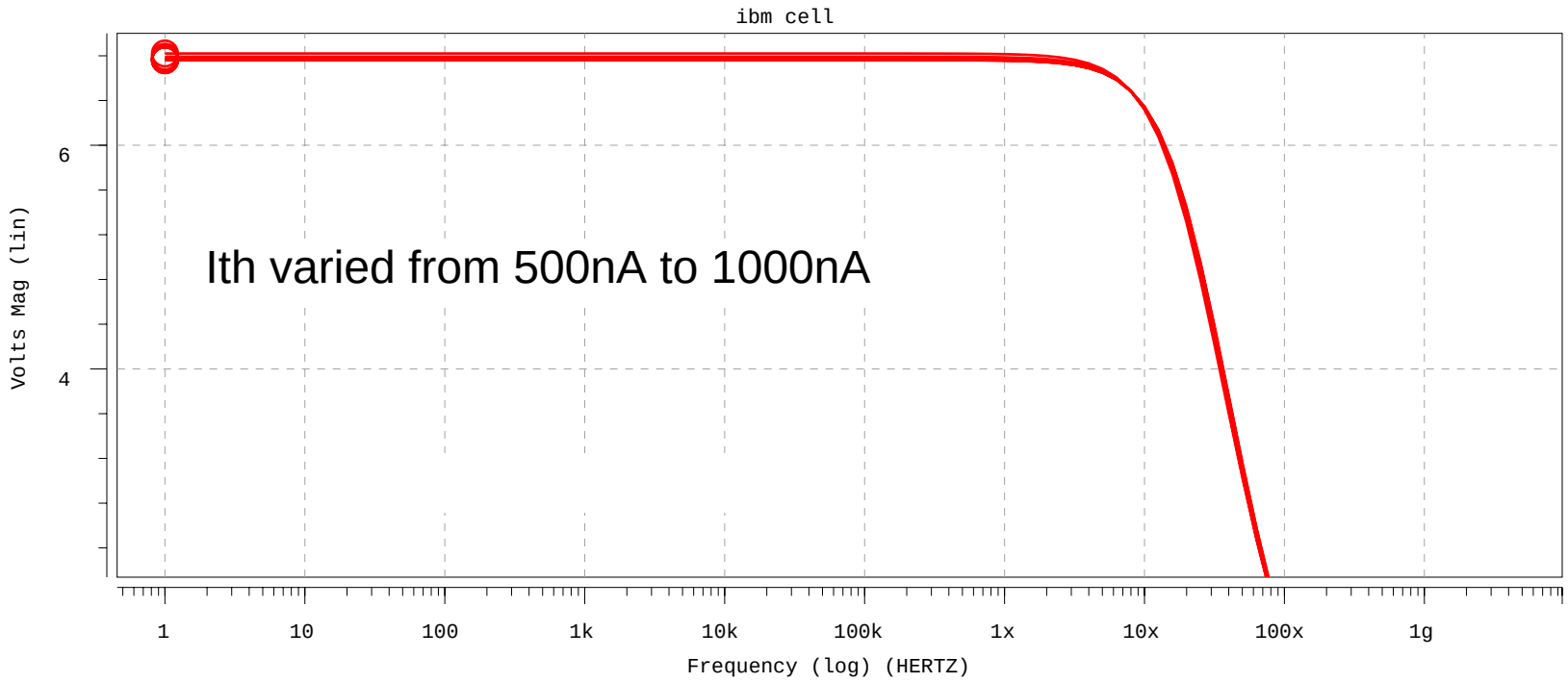

ibm cell
replica
DC level
Measures (lin)
1.1205
1.12
1.1195
1.119
0
10n
20n
30n
40n
50n
60n
70n
80n
90n
100n
Outer Result (lin) (0:ileak)

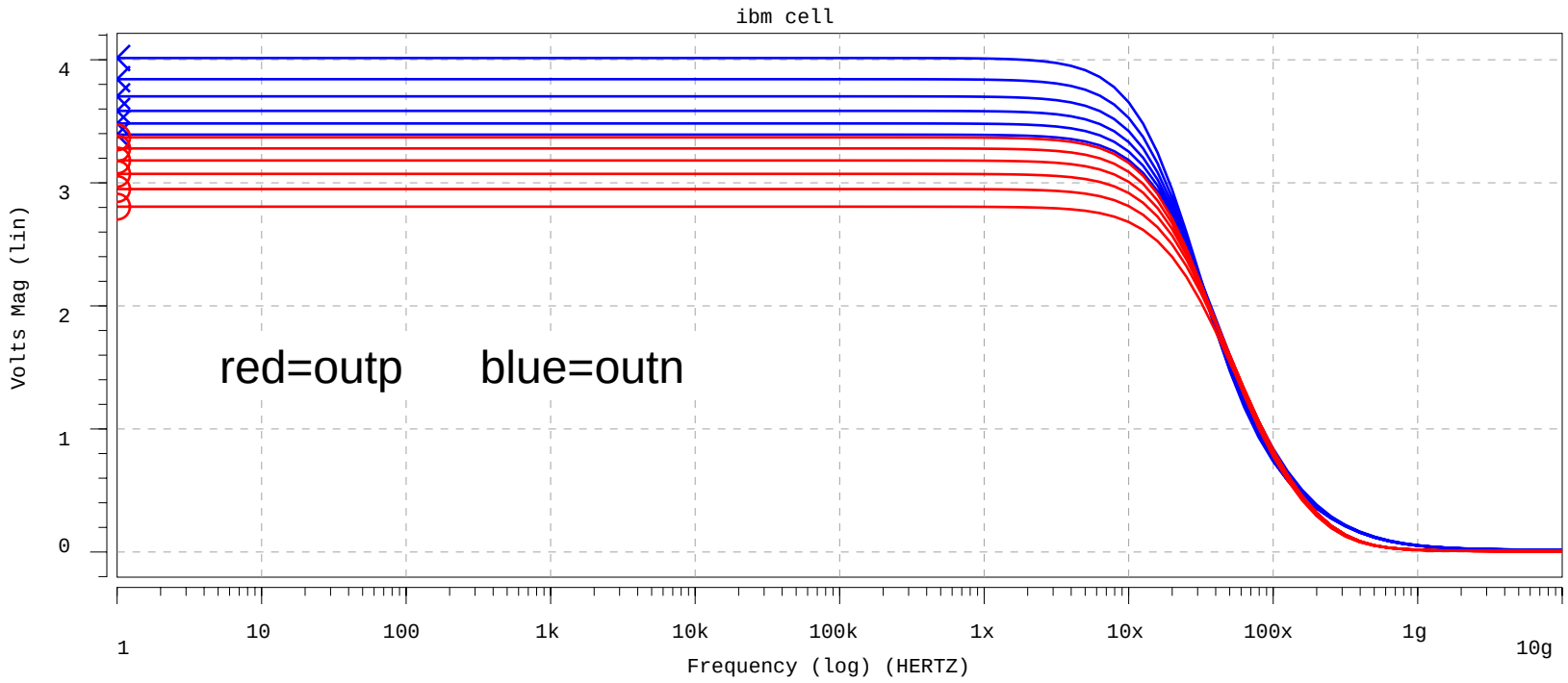

ibm cell
peaking value
Measures (lin)
105m
104.8m
104.6m
104.4m
104.2m
104m
0
10n
20n
30n
40n
50n
60n
70n
80n
90n
100n
Outer Result (lin) (0:ileak)

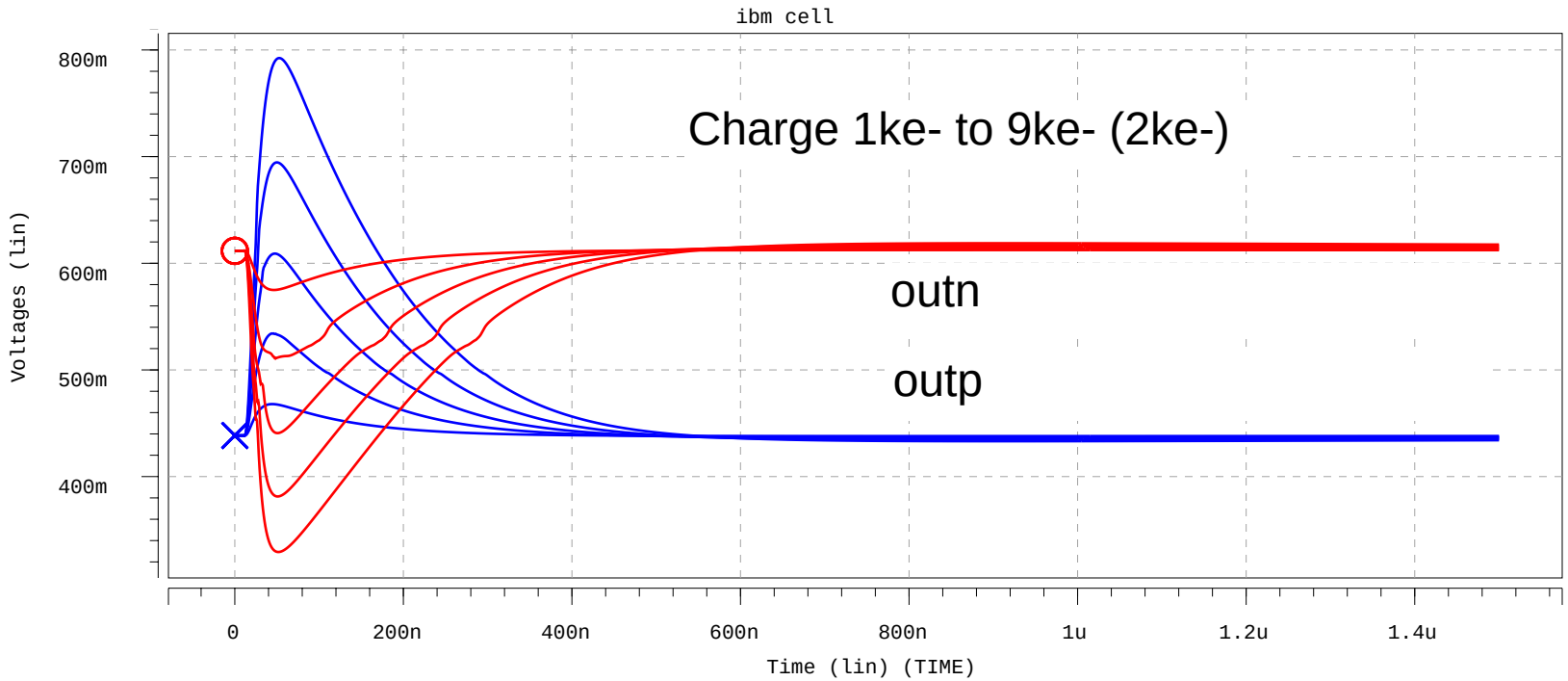

ibm cell
rise time
Measures (lin)
14.2n
14.18n
14.16n
14.14n
0
10n
20n
30n
40n
50n
60n
70n
80n
90n
100n
Outer Result (lin) (0:ileak)

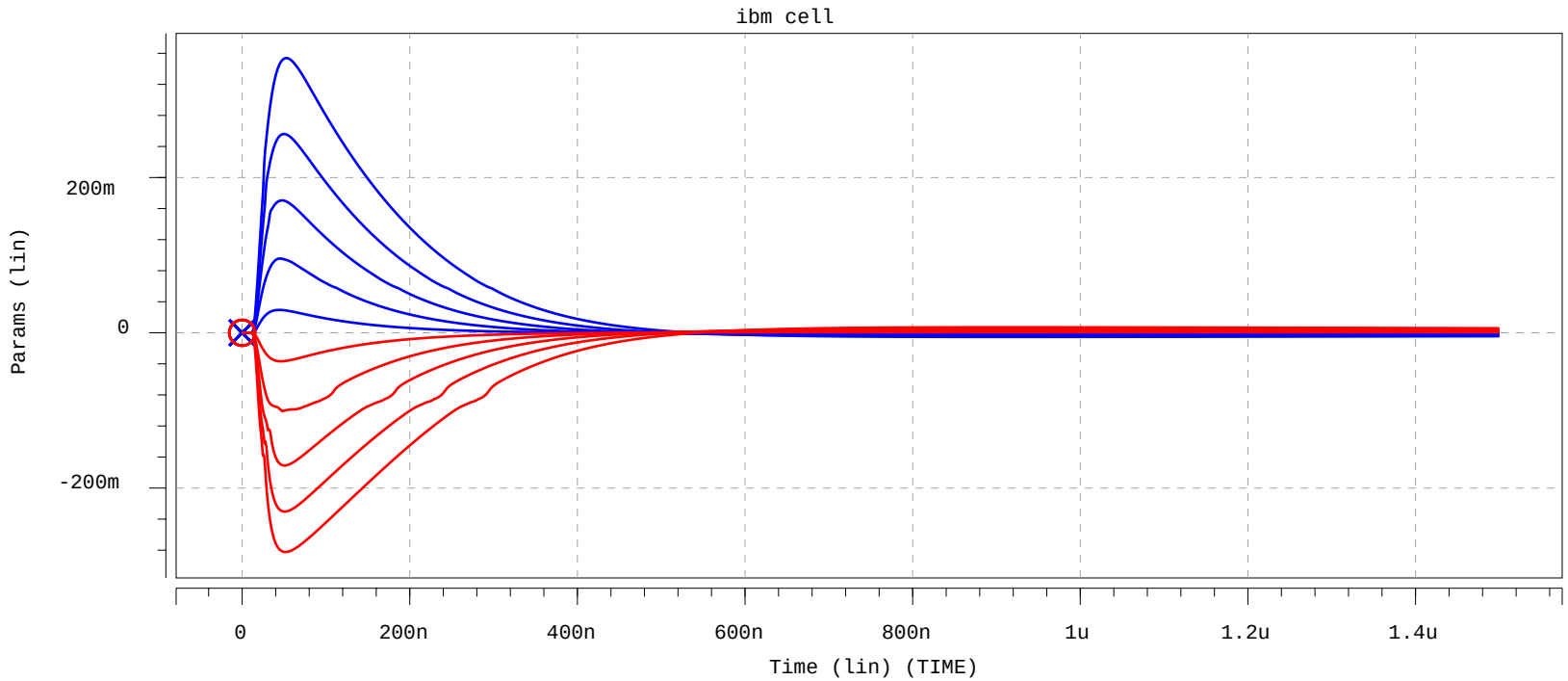

ibm cell
Current Y=1.66e+001
Current X=2.67e+007
BW=26.7MHz
Volts dB (lin)
0
-20
-40
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)

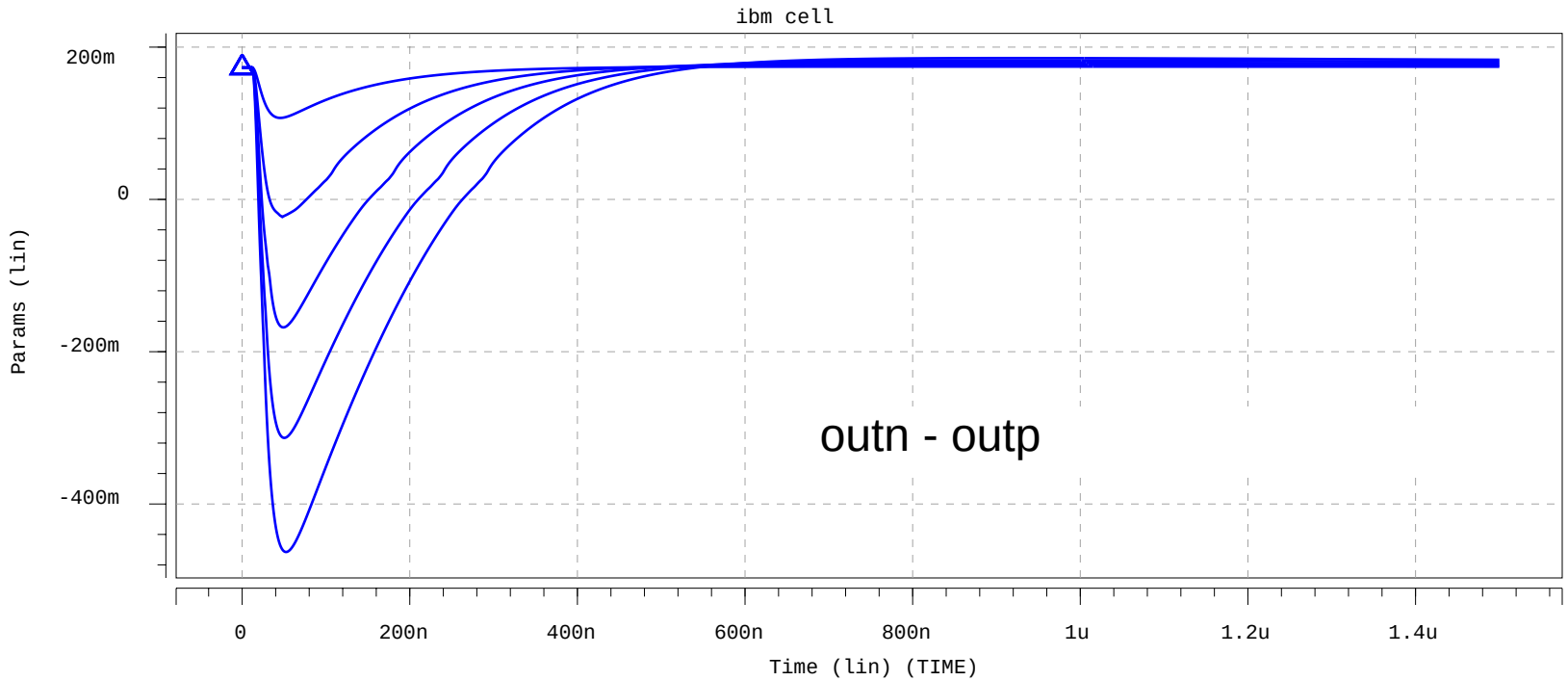

ibm cell
Current Y=6.76e+000
follower gain = 0.77
differential gain of the second amp = 8.8
=> total gain = 6.8
Current Y=7.69e-001
Volts Mag (lin)
6
4
2
0
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)

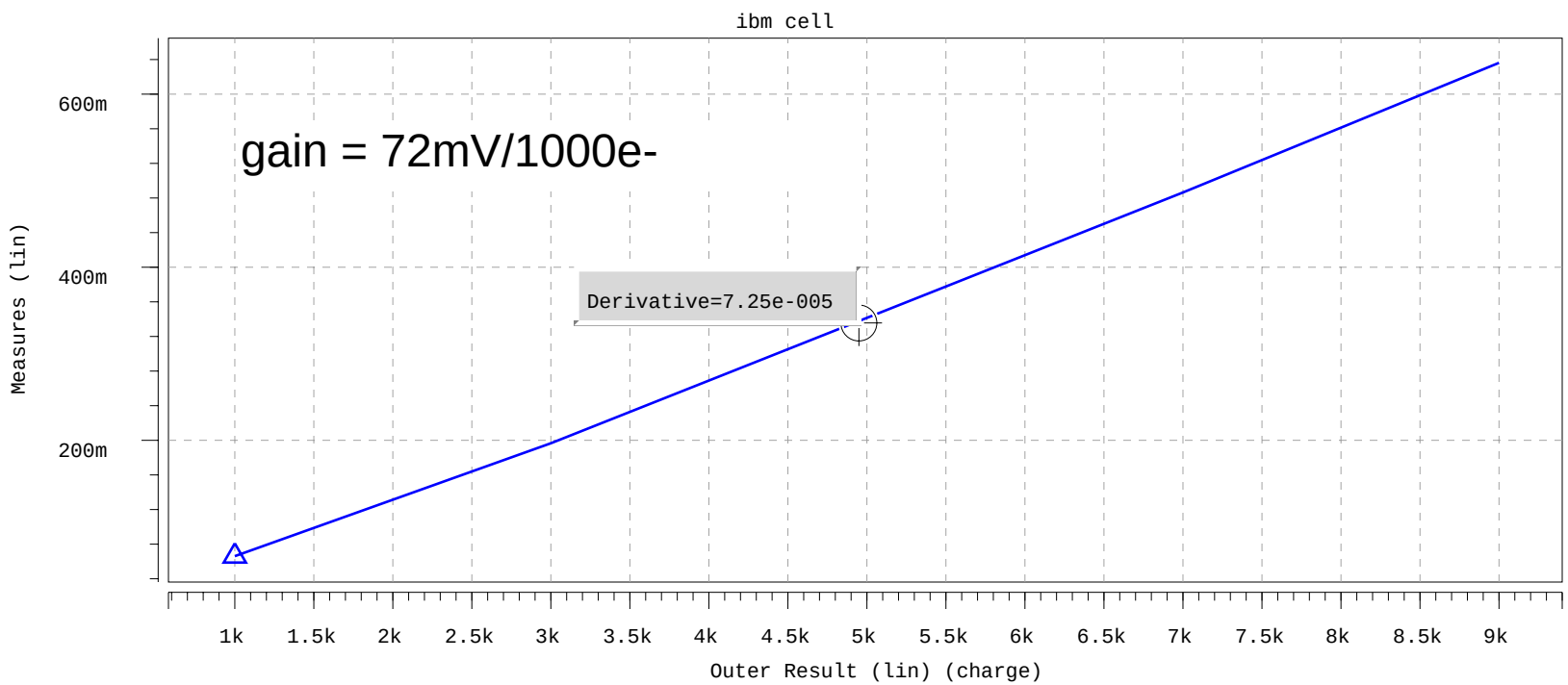

ibm cell
Ith varied from 500nA to 1000nA
Volts Mag (lin)
6
4
1
10
100
1k
10k
100k
1x
10x
100x
1g
Frequency (log) (HERTZ)

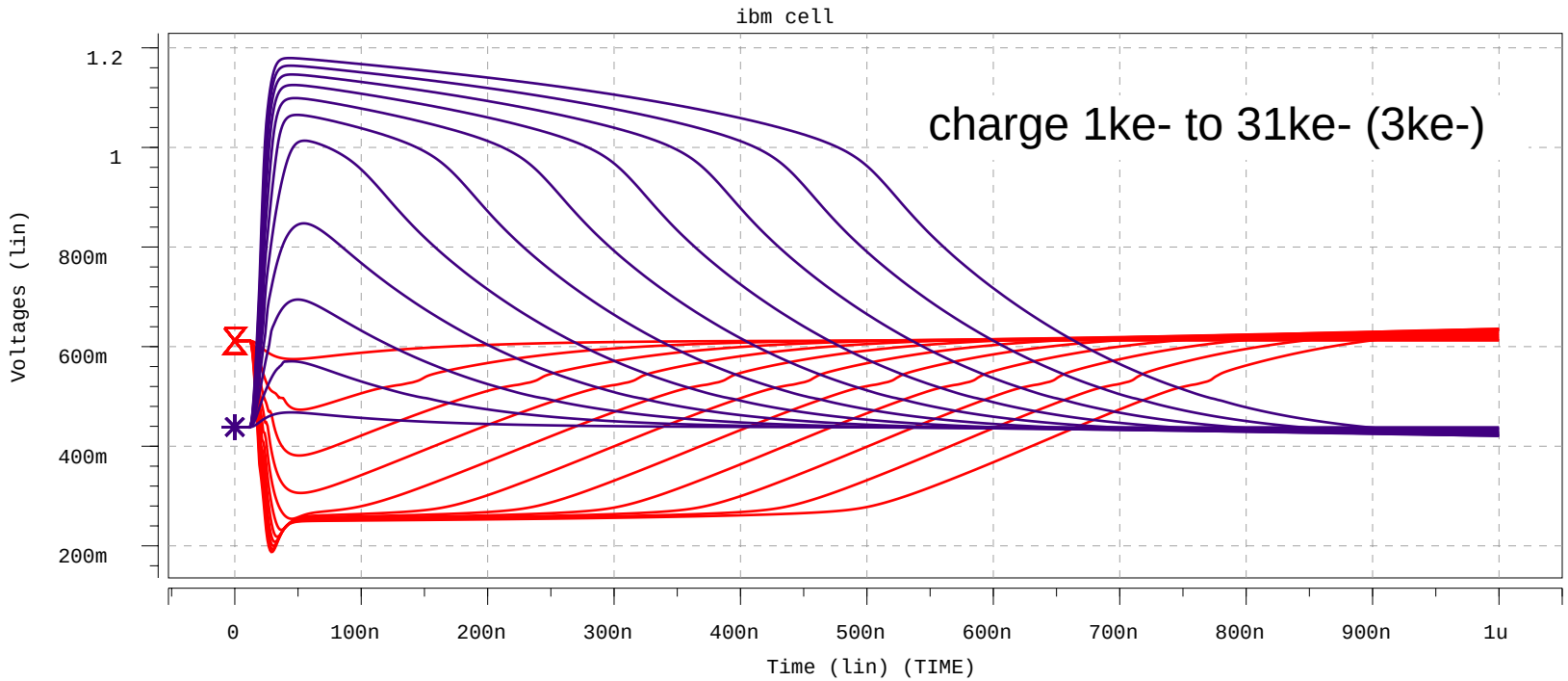

ibm cell
red=outp
blue=outn
Volts Mag (lin)
4
3
2
1
0
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)

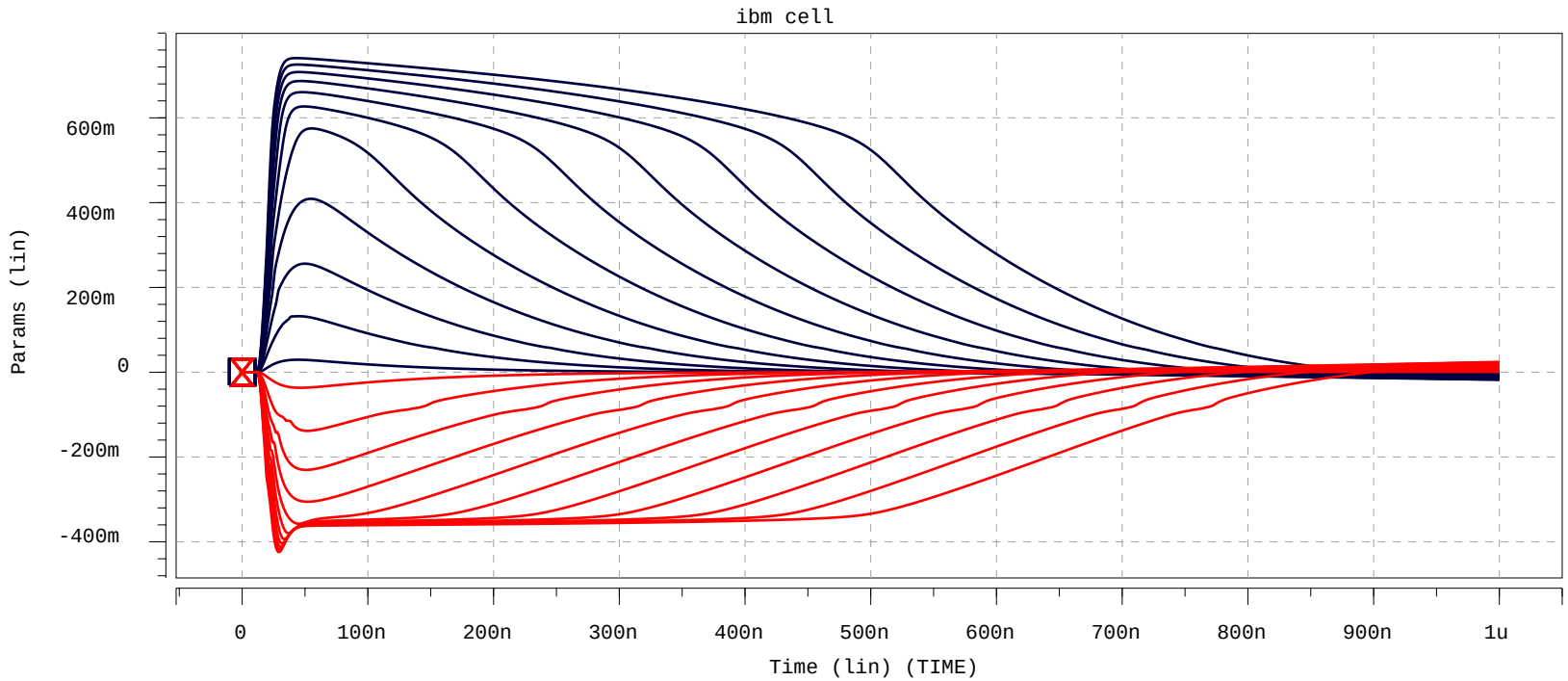

ibm cell
Charge 1ke- to 9ke- (2ke-)
outn
outp
Voltages (lin)
800m
700m
600m
500m
400m
0
200n
400n
600n
800n
1u
1.2u
1.4u
Time (lin) (TIME)

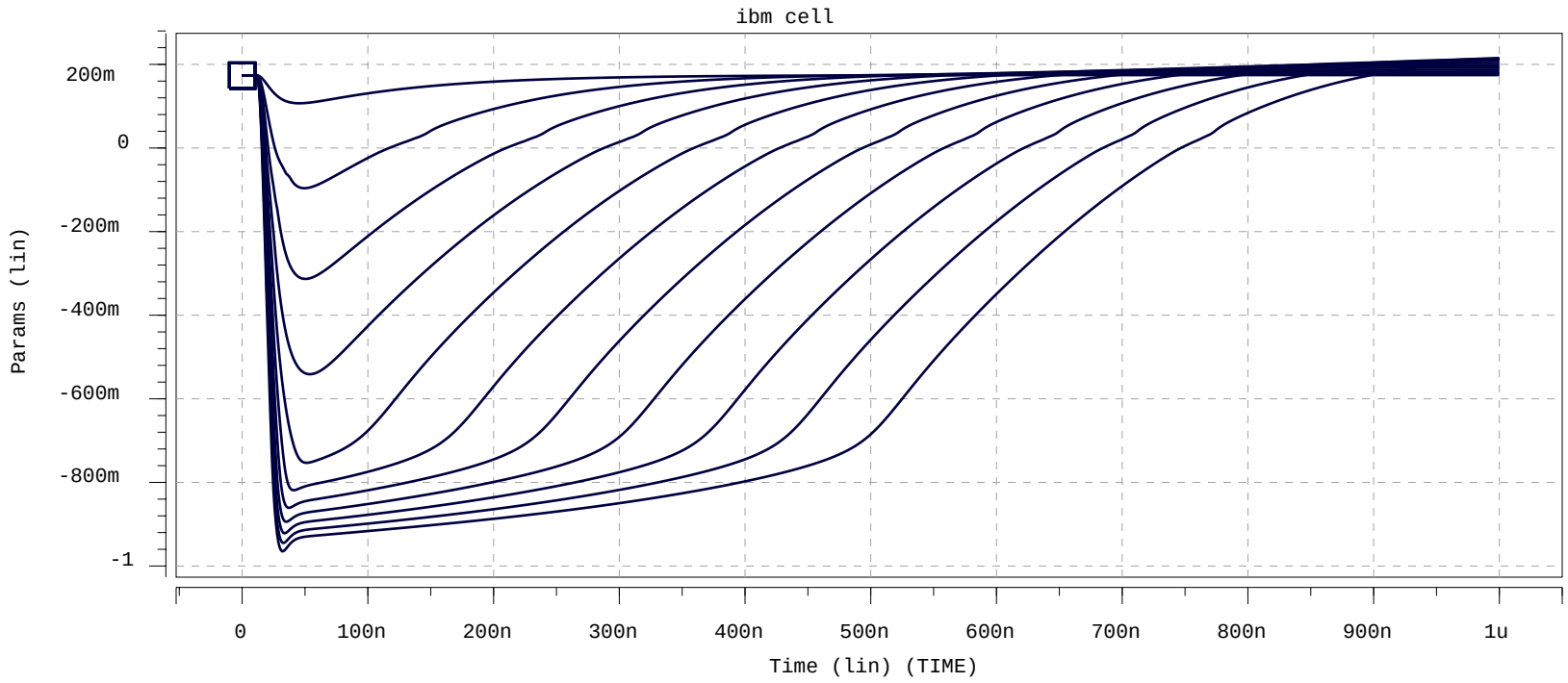

ibm cell
Params (lin)
200m
0
-200m
0
200n
400n
600n
800n
1u
1.2u
1.4u
Time (lin) (TIME)

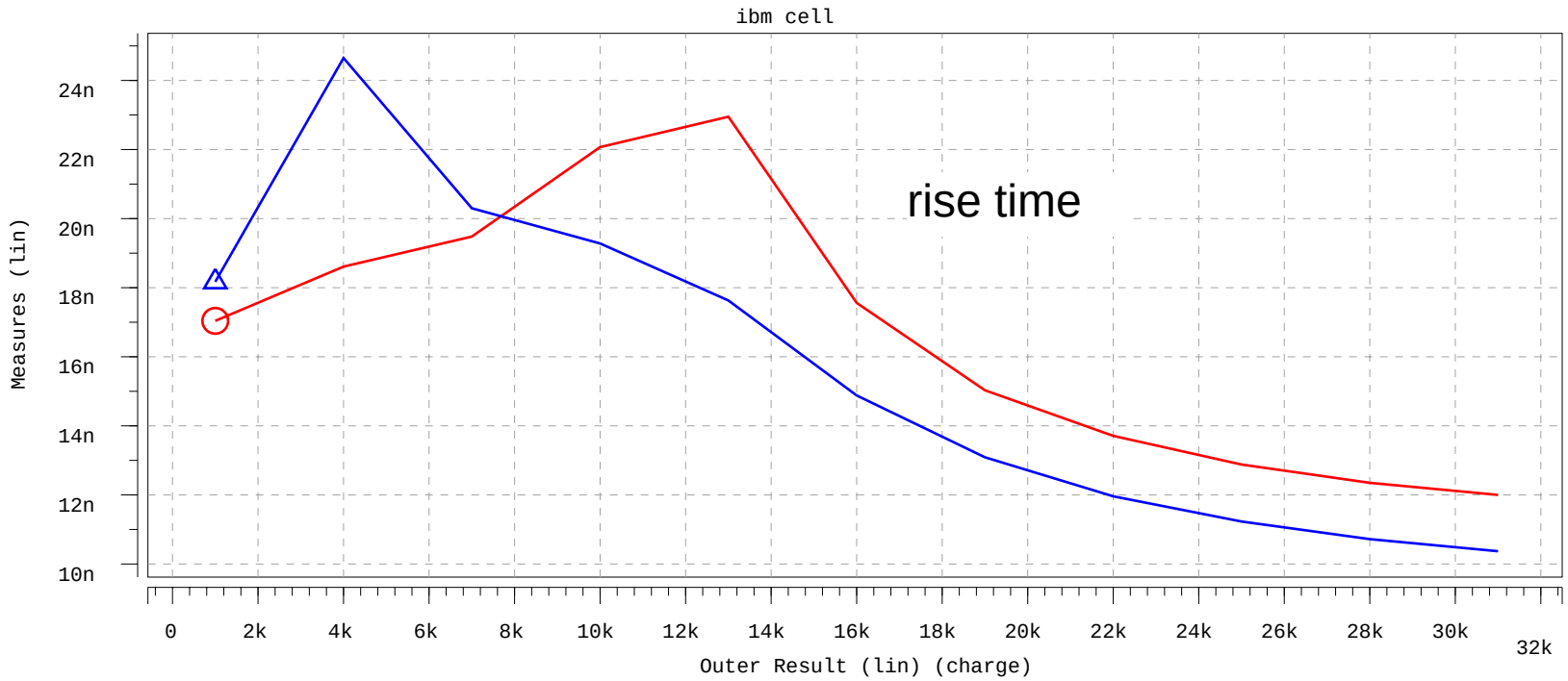

ibm cell
200m
0
-200m
-400m
Params (lin)
outn - outp
0
200n
400n
600n
800n
1u
1.2u
1.4u
Time (lin) (TIME)

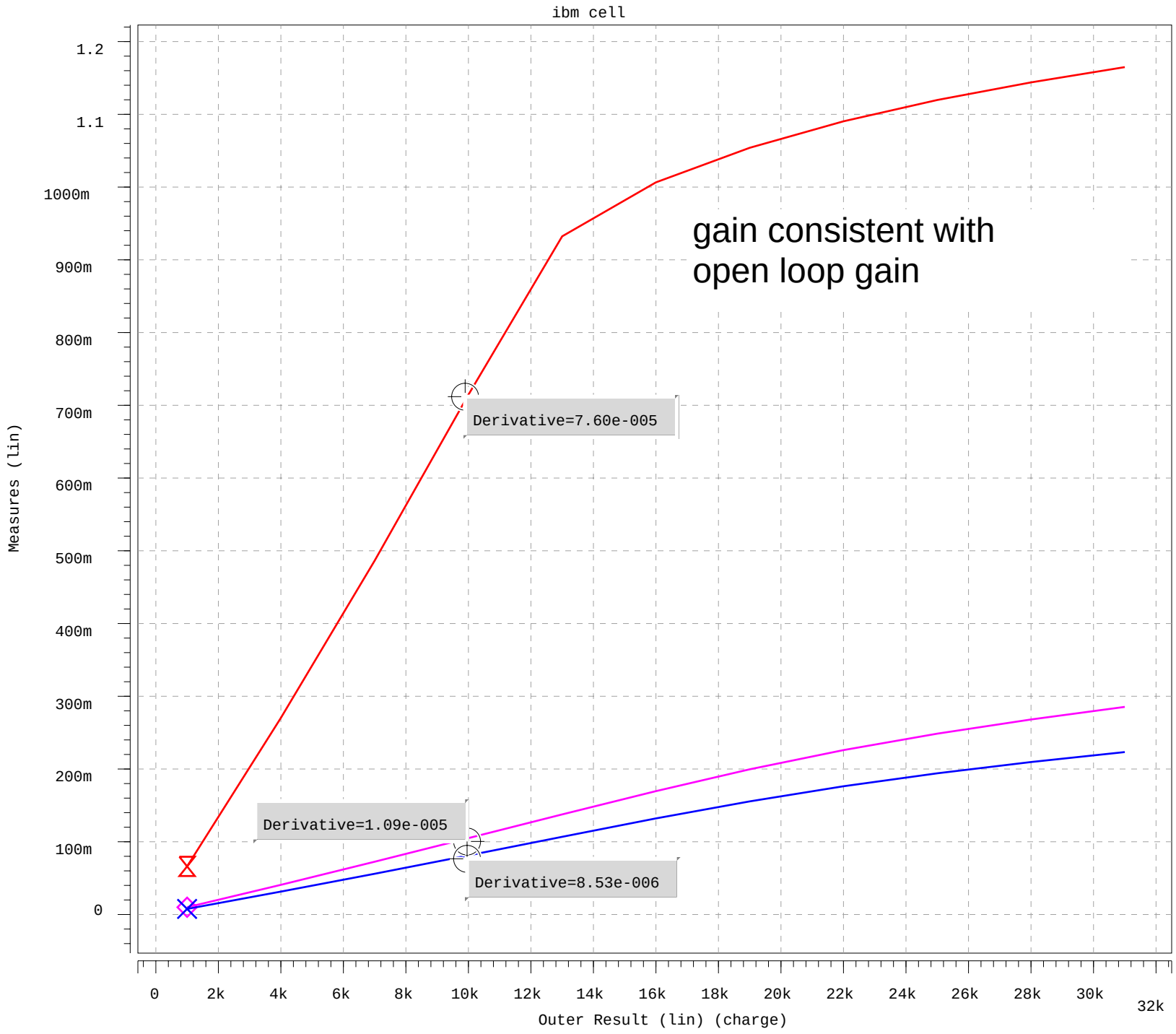

ibm cell
600m
400m
200m
Measures (lin)
gain = 72mV/1000e-
Derivative=7.25e-005
1k
1.5k
2k
2.5k
3k
3.5k
4k
4.5k
5k
5.5k
6k
6.5k
7k
7.5k
8k
8.5k
9k
Outer Result (lin) (charge)

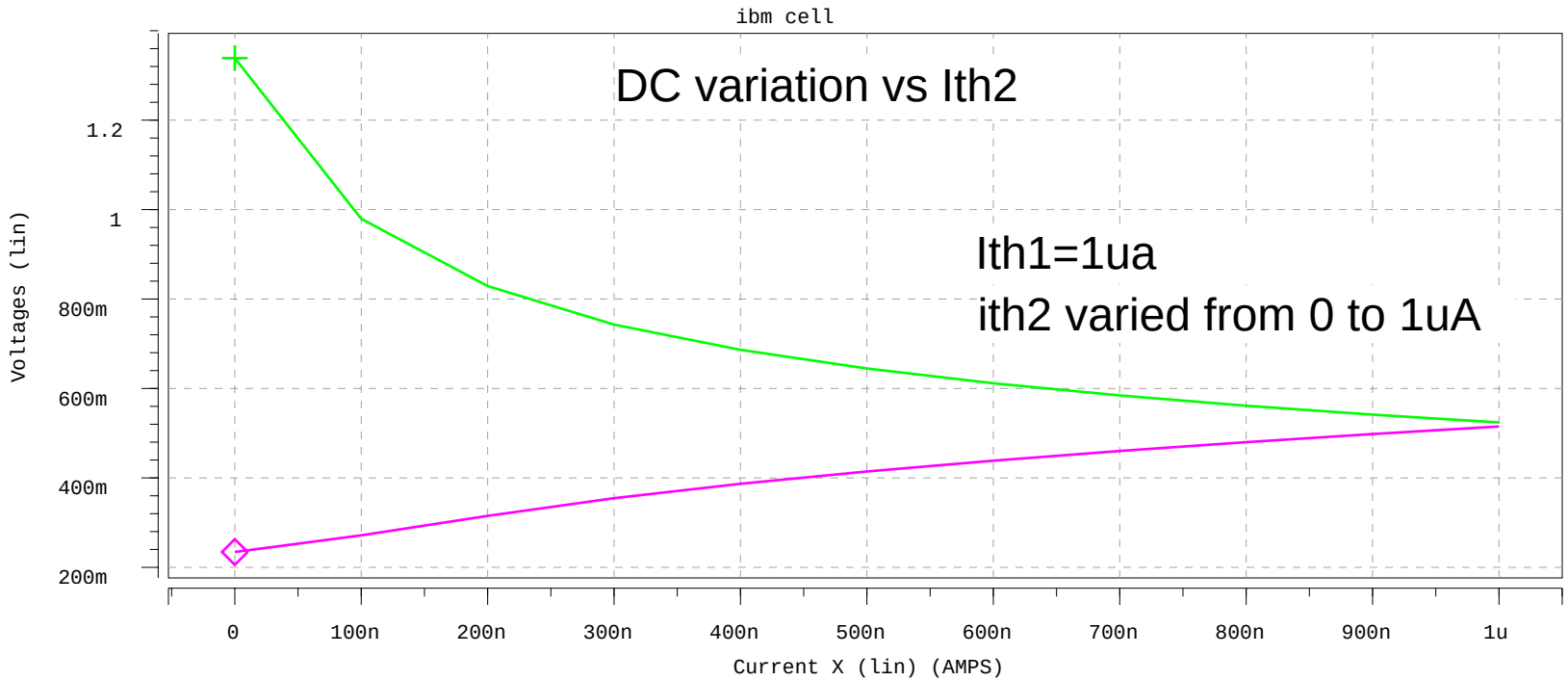

ibm cell
charge 1ke- to 31ke- (3ke-)
Voltages (lin)
1.2
1
800m
600m
400m
200m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

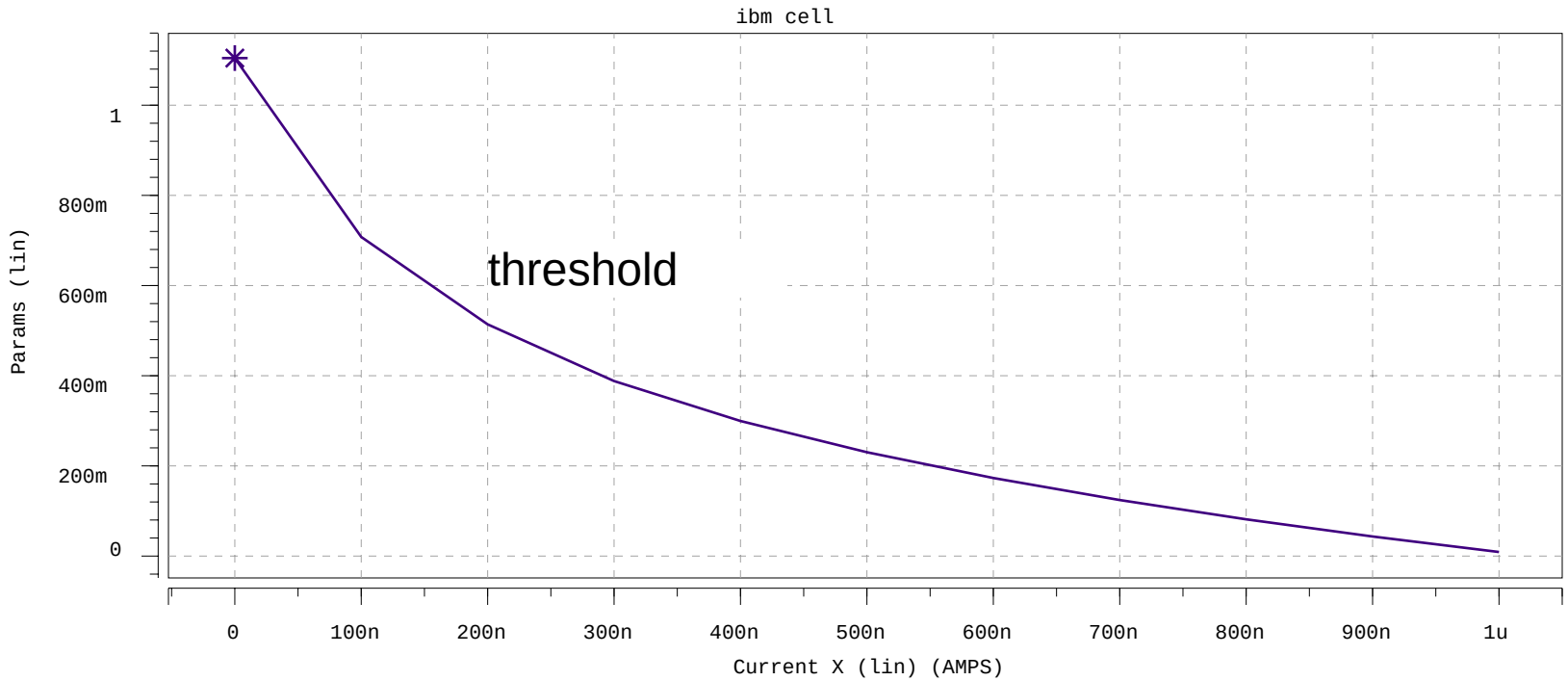

ibm cell
Params (lin)
600m
400m
200m
0
-200m
-400m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

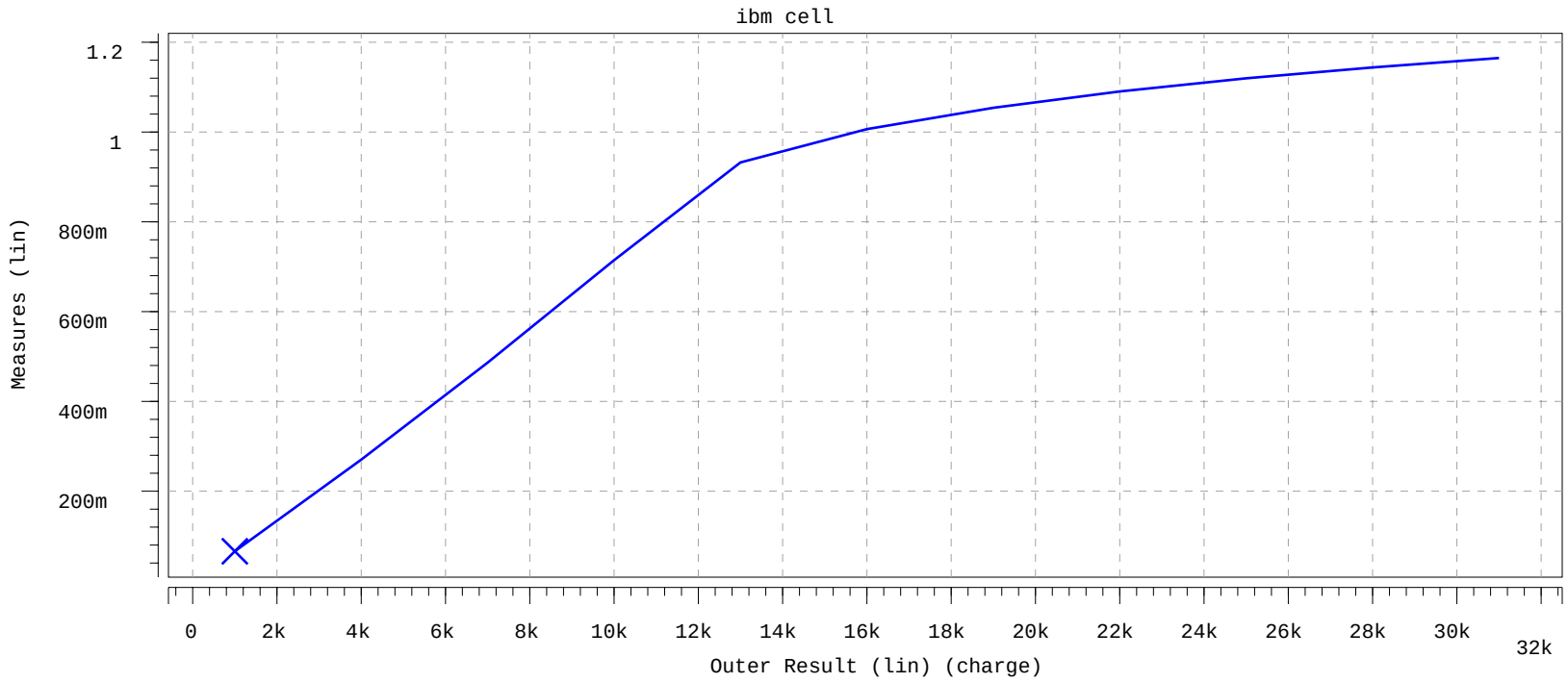

ibm cell
200m
0
-200m
-400m
-600m
-800m
-1
Params (lin)
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

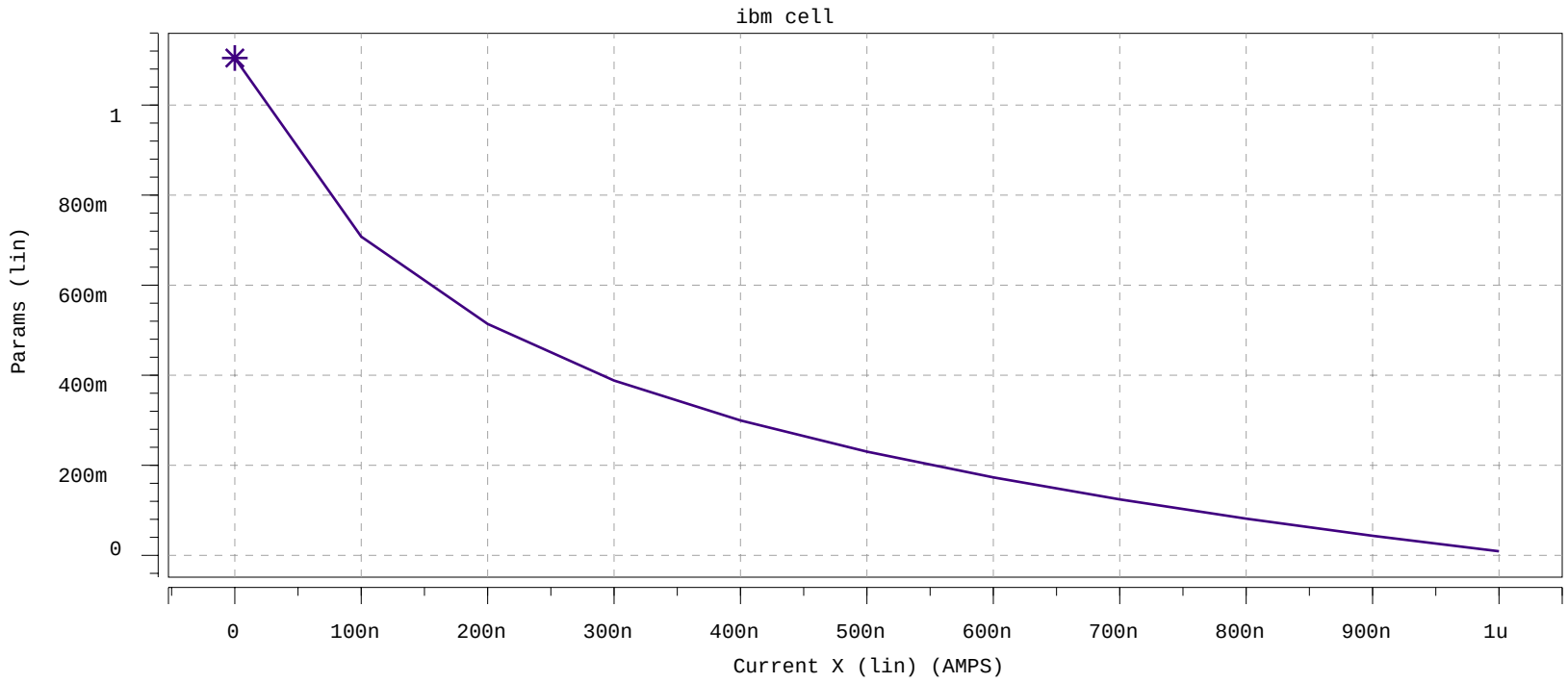

ibm cell
rise time
24n
22n
20n
18n
16n
14n
12n
10n
Measures (lin)
0
2k
4k
6k
8k
10k
12k
14k
16k
18k
20k
22k
24k
26k
28k
30k
32k
Outer Result (lin) (charge)

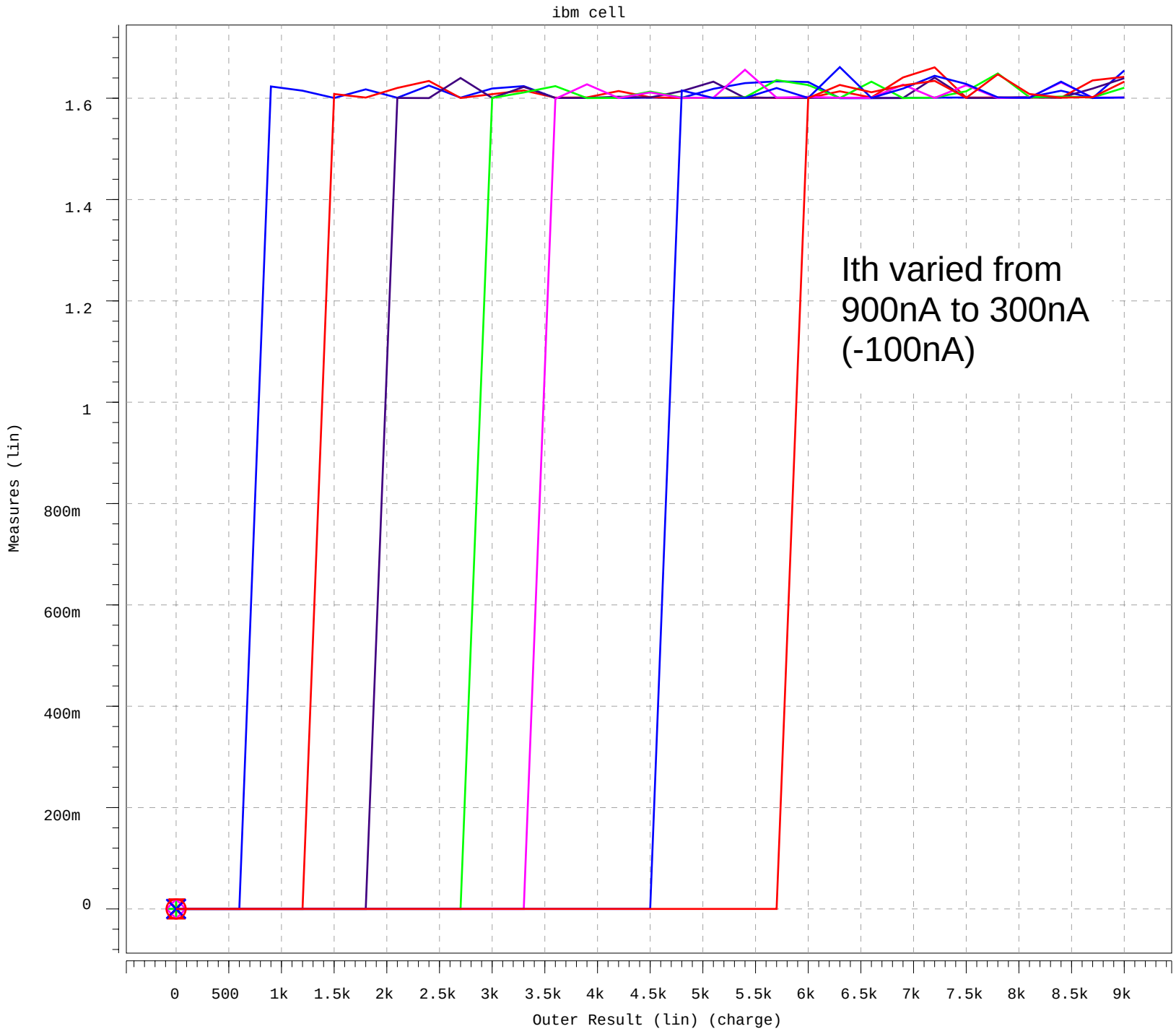

ibm cell
gain consistent with
open loop gain
Derivative=7.60e-005
Derivative=1.09e-005
Derivative=8.53e-006
Measures (lin)
1.2
1.1
1000m
900m
800m
700m
600m
500m
400m
300m
200m
100m
0
0
2k
4k
6k
8k
10k
12k
14k
16k
18k
20k
22k
24k
26k
28k
30k
32k
Outer Result (lin) (charge)

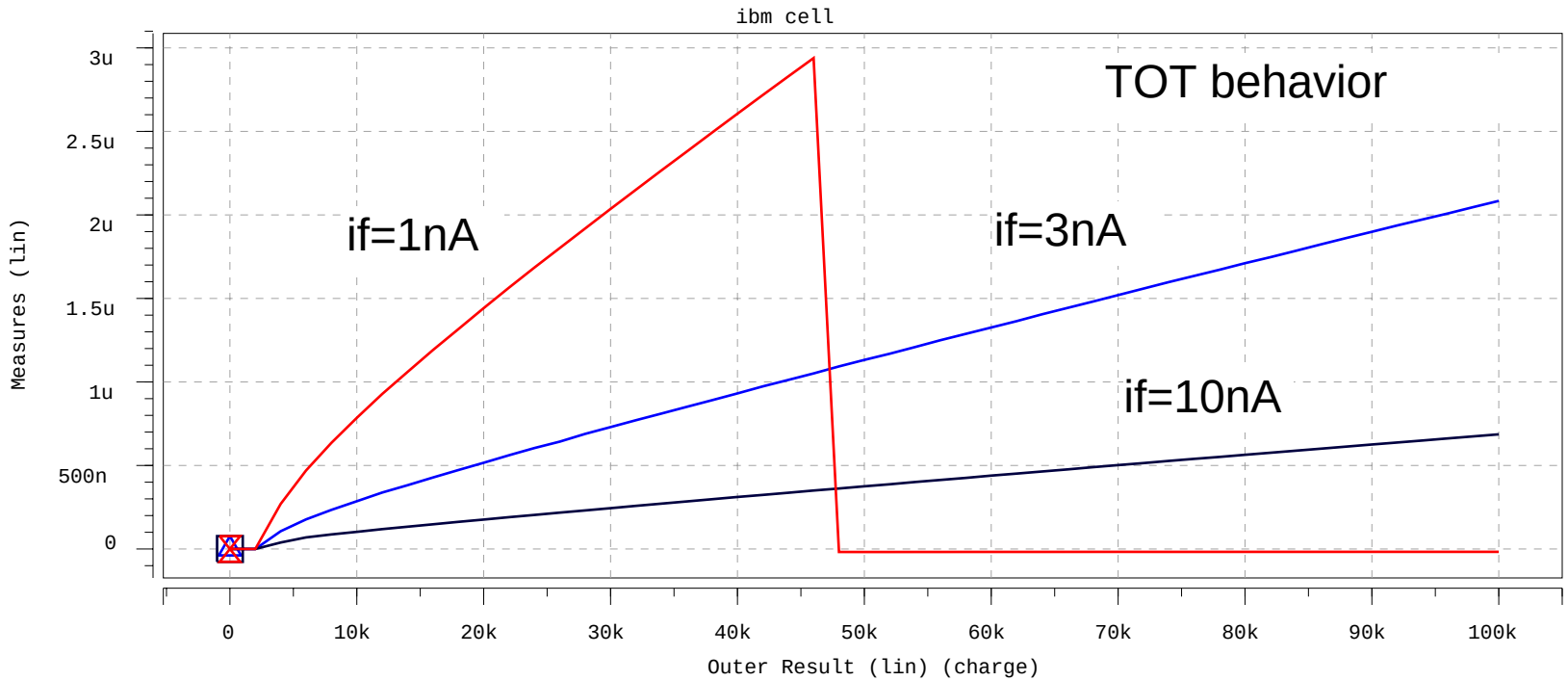

ibm cell
DC variation vs Ith2
Ith1=1ua
ith2 varied from 0 to 1uA
Voltages (lin)
1.2
1
800m
600m
400m
200m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Current X (lin) (AMPS)

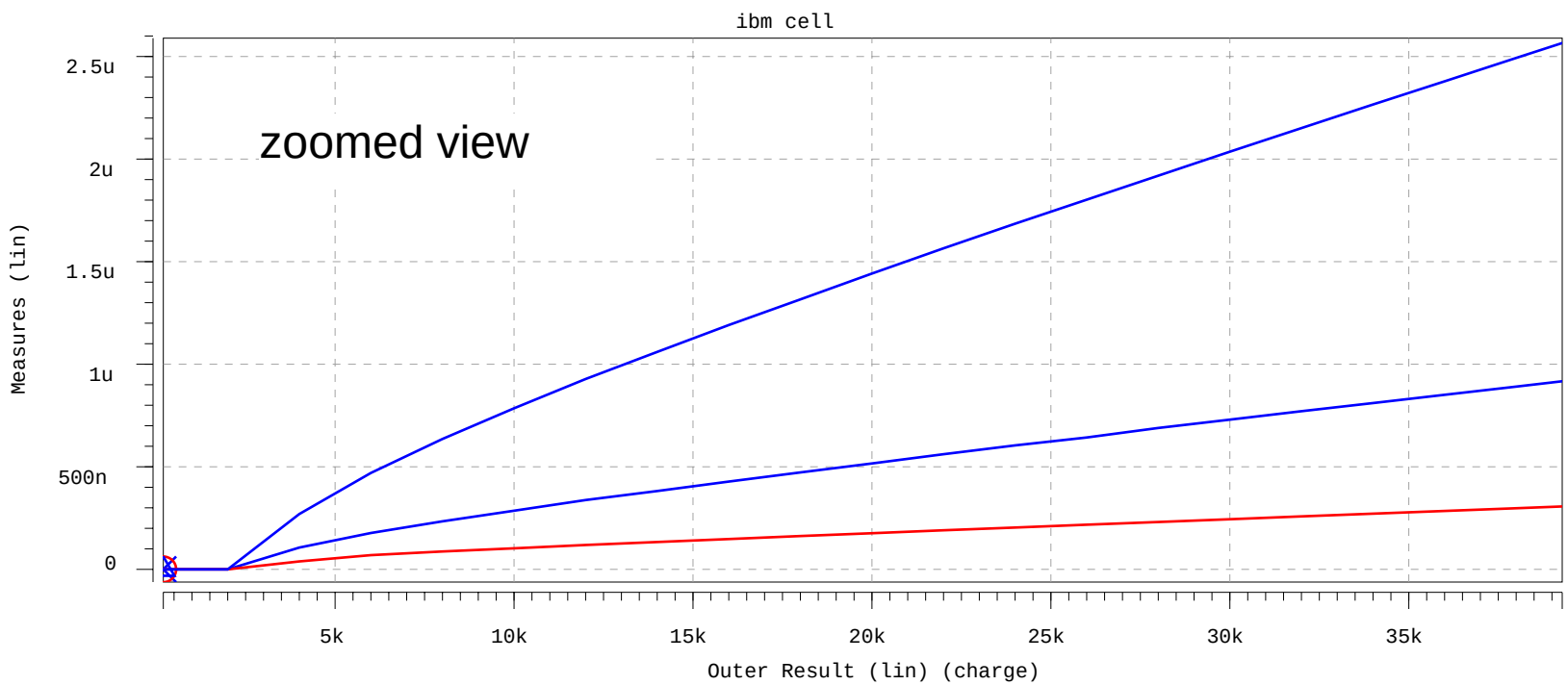

ibm cell
threshold
Params (lin)
1
800m
600m
400m
200m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Current X (lin) (AMPS)

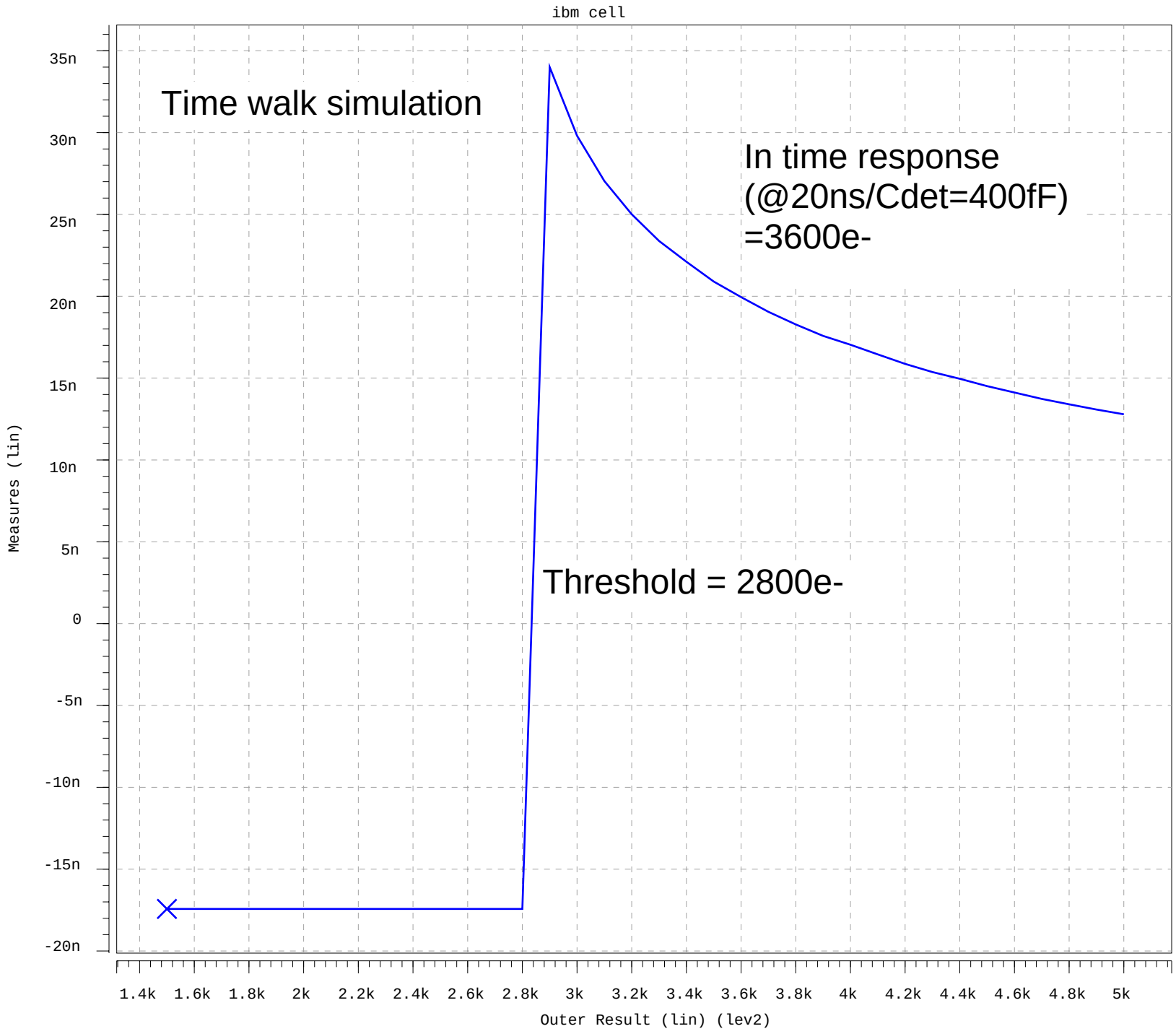

ibm cell
Measures (lin)
1.2
1
800m
600m
400m
200m
0
2k
4k
6k
8k
10k
12k
14k
16k
18k
20k
22k
24k
26k
28k
30k
32k
Outer Result (lin) (charge)

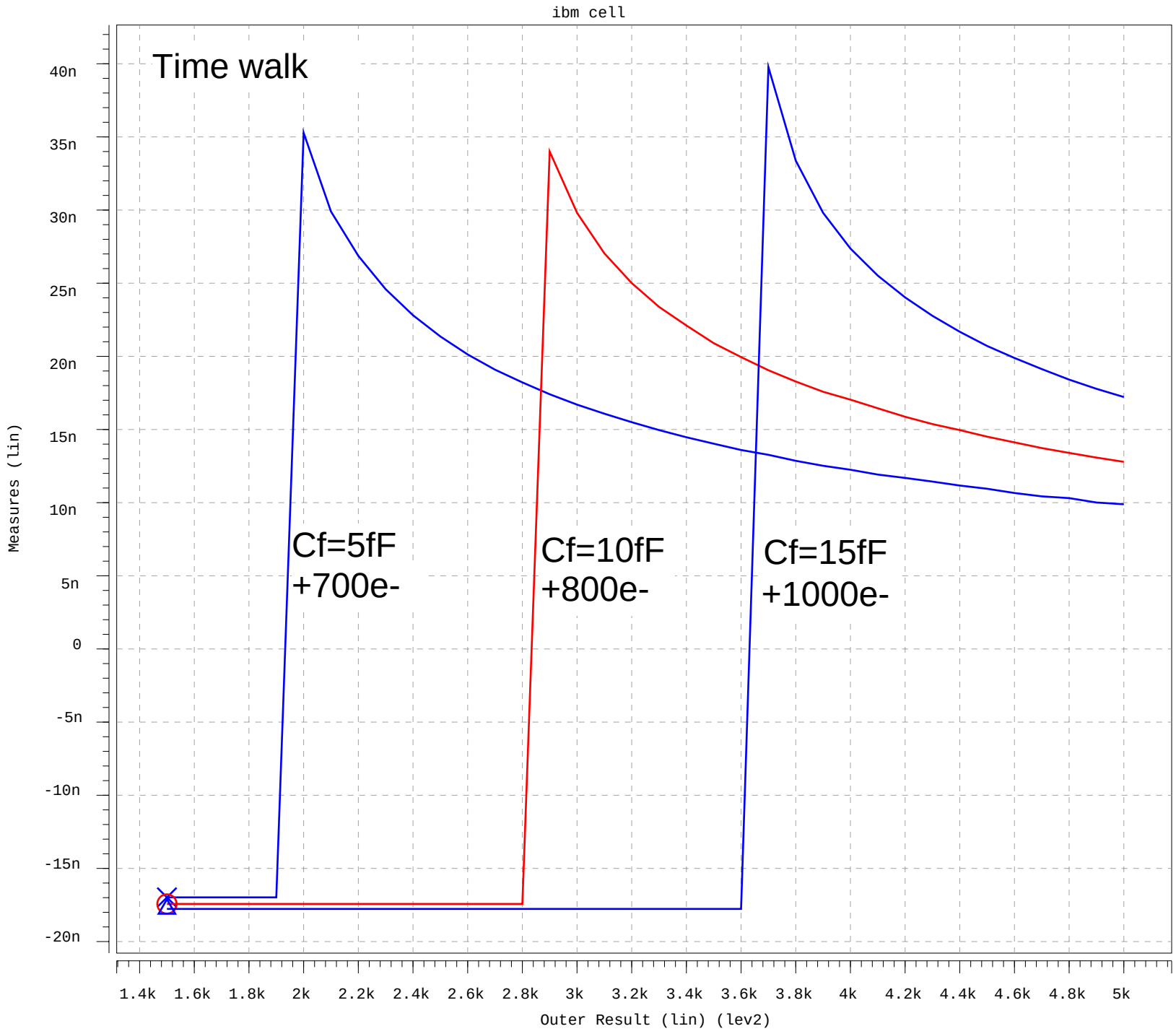

ibm cell
Params (lin)
1
800m
600m
400m
200m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Current X (lin) (AMPS)


ibm cell
Ith varied from
900nA to 300nA
(-100nA)
Measures (lin)
1.6
1.4
1.2
1
800m
600m
400m
200m
0
0
500
1k
1.5k
2k
2.5k
3k
3.5k
4k
4.5k
5k
5.5k
6k
6.5k
7k
7.5k
8k
8.5k
9k
Outer Result (lin) (charge)

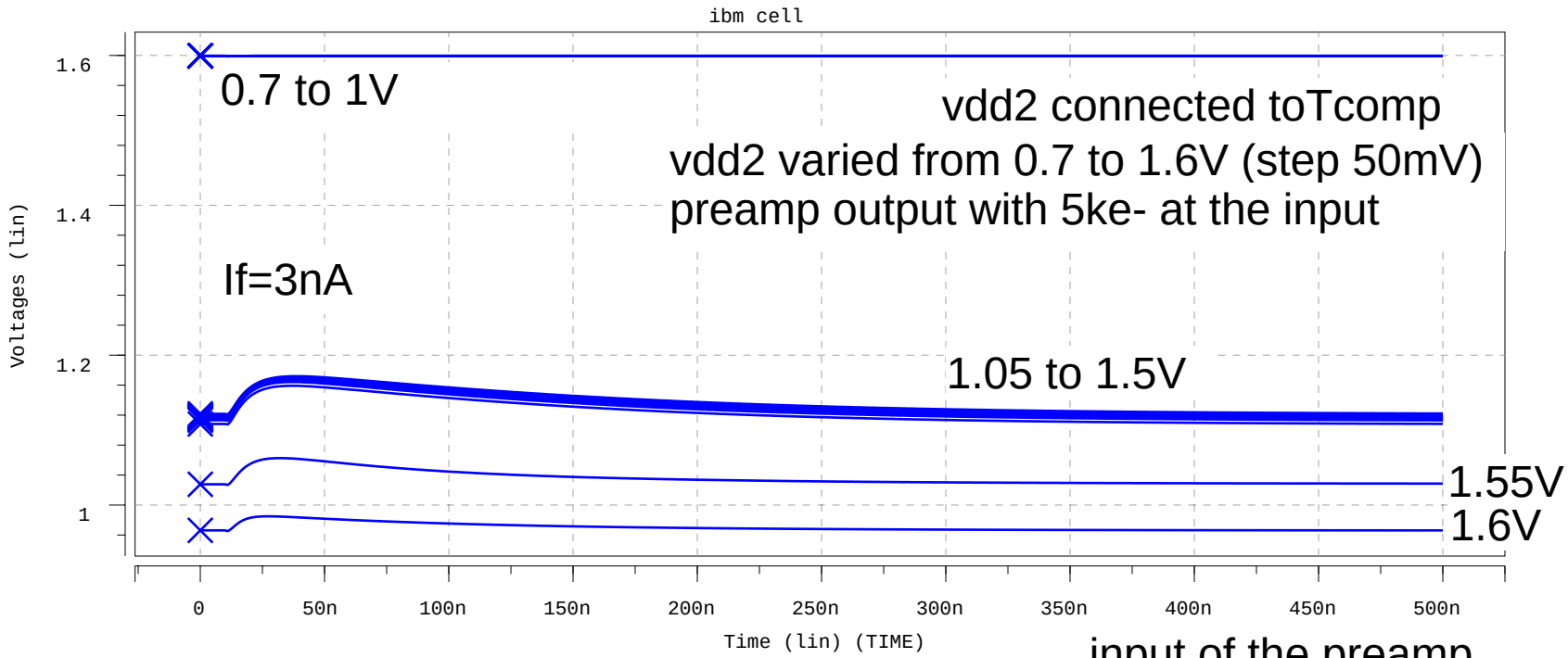

ibm cell
TOT behavior
if=1nA
if=3nA
if=10nA
Measures (lin)
3u
2.5u
2u
1.5u
1u
500n
0
0
10k
20k
30k
40k
50k
60k
70k
80k
90k
100k
Outer Result (lin) (charge)


ibm cell
zoomed view
Measures (lin)
2.5u
2u
1.5u
1u
500n
0
5k
10k
15k
20k
25k
30k
35k
Outer Result (lin) (charge)

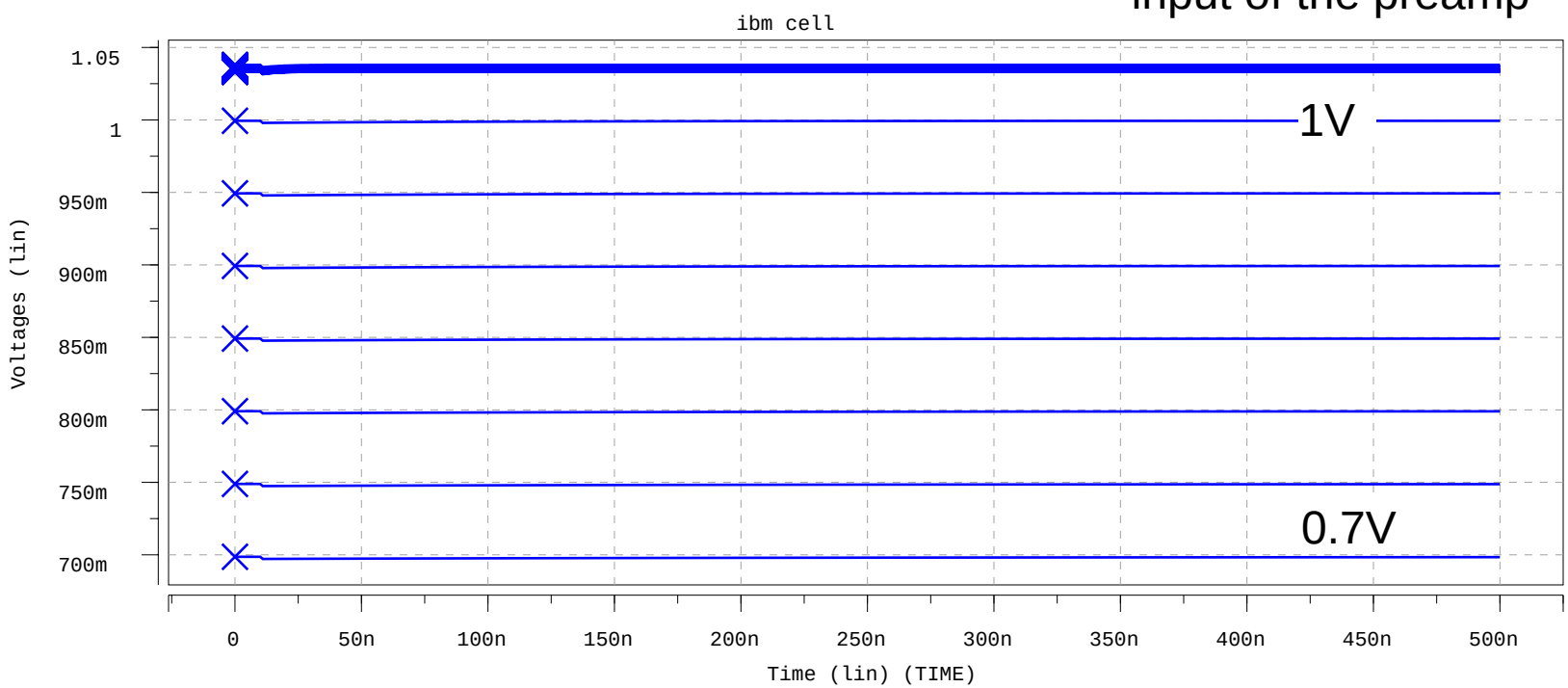

ibm cell
Time walk simulation
In time response
(@20ns/Cdet=400fF)
=3600e-
Threshold = 2800e-
35n
30n
25n
20n
15n
10n
5n
0
-5n
-10n
-15n
-20n
Measures (lin)
1.4k
1.6k
1.8k
2k
2.2k
2.4k
2.6k
2.8k
3k
3.2k
3.4k
3.6k
3.8k
4k
4.2k
4.4k
4.6k
4.8k
5k
Outer Result (lin) (lev2)

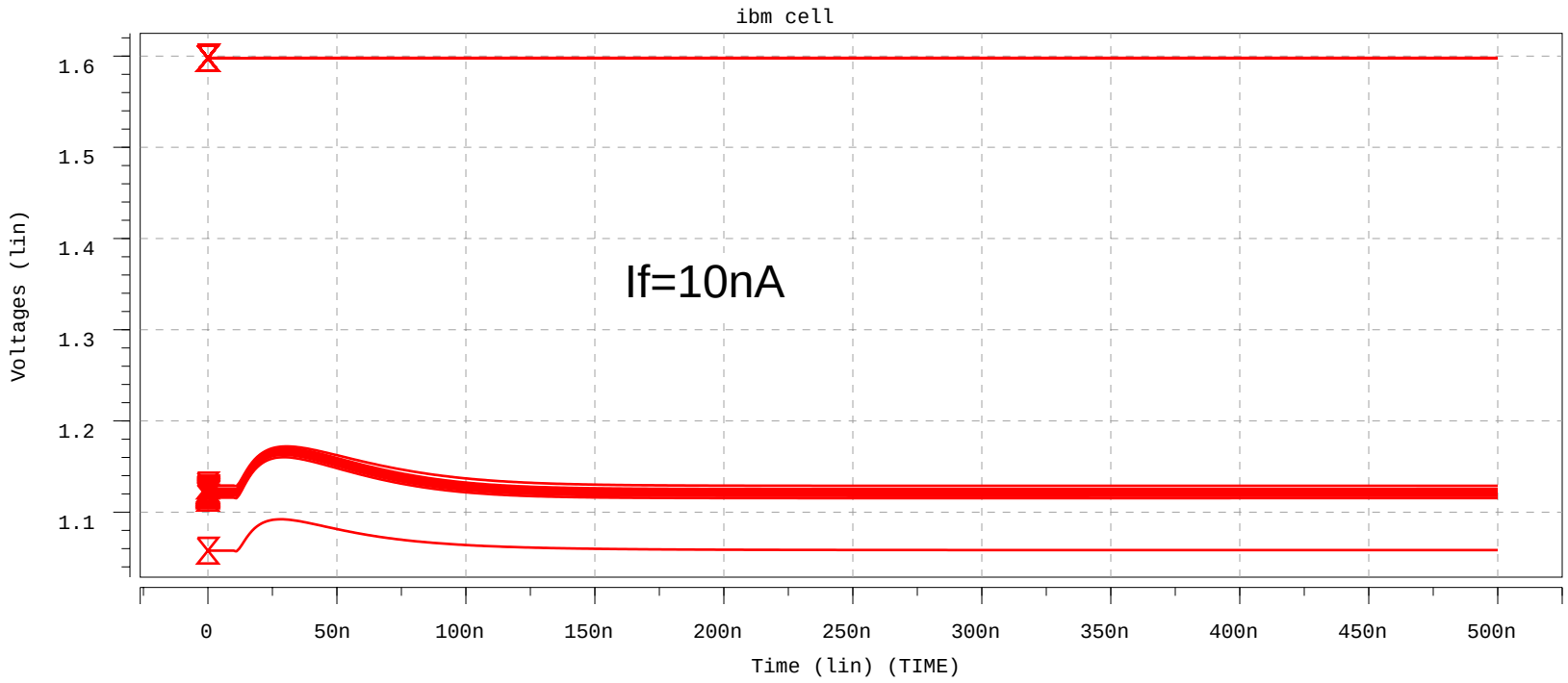

ibm cell
Time walk
Cf=5fF
+700e-
Cf=10fF
+800e-
Cf=15fF
+1000e-
Measures (lin)
40n
35n
30n
25n
20n
15n
10n
5n
0
-5n
-10n
-15n
-20n
1.4k
1.6k
1.8k
2k
2.2k
2.4k
2.6k
2.8k
3k
3.2k
3.4k
3.6k
3.8k
4k
4.2k
4.4k
4.6k
4.8k
5k
Outer Result (lin) (lev2)

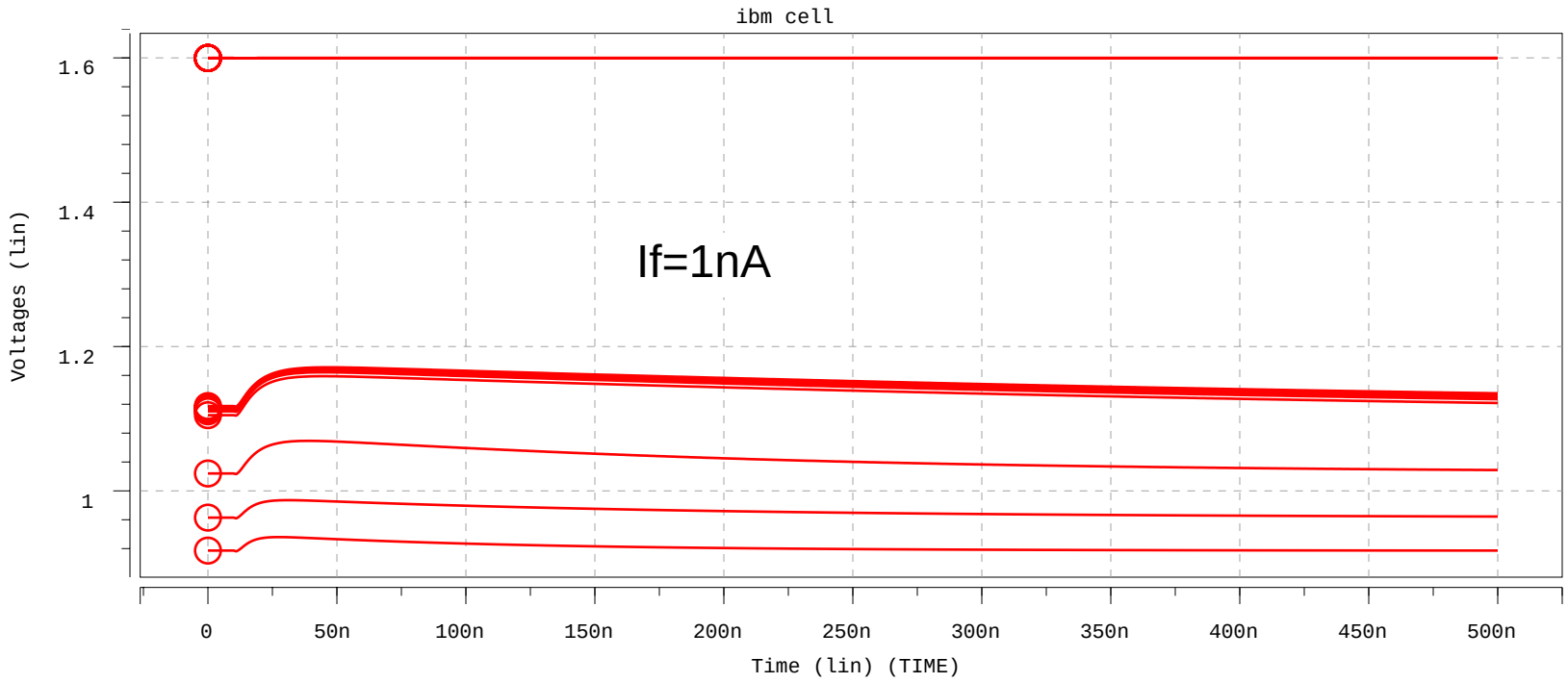
	Noise after preamp				Noise before discriminator			
Sensor capacitance (fF)	RMS noise at the output (mV)	Tin Contribution (mV)	Peaking value of 2000e- (mV)	ENC (e-)	RMS noise at the output (mV)	Tin Contribution (mV)	Peaking value of 2000e- (mV)	ENC (e-)
0	2.25	0.93	23.6	190	15.9	3.16	138	230
100	2.8	1.41	21.8	256	18.07	6.07	138	261
200	3.27	1.76	21.1	309	20.51	8.51	137	299
300	3.69	2.06	20.6	358	22.96	10.64	135	340
400	4.06	2.32	20.1	403	25.34	12.52	133	380
500	4.41	2.55	19.7	447	27.64	14.23	131	421
600	4.73	2.76	19.3	490	29.84	15.8	129	462

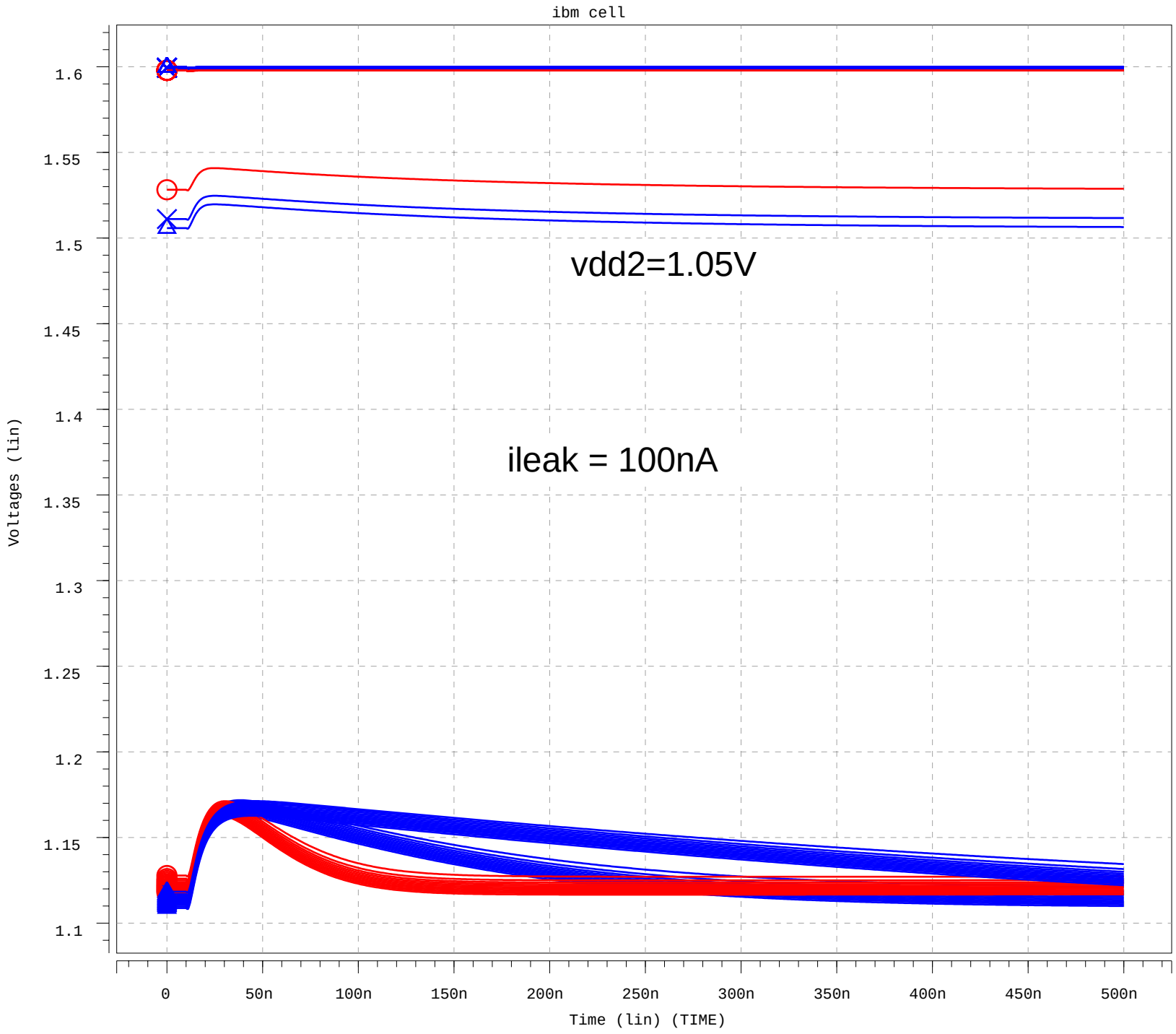


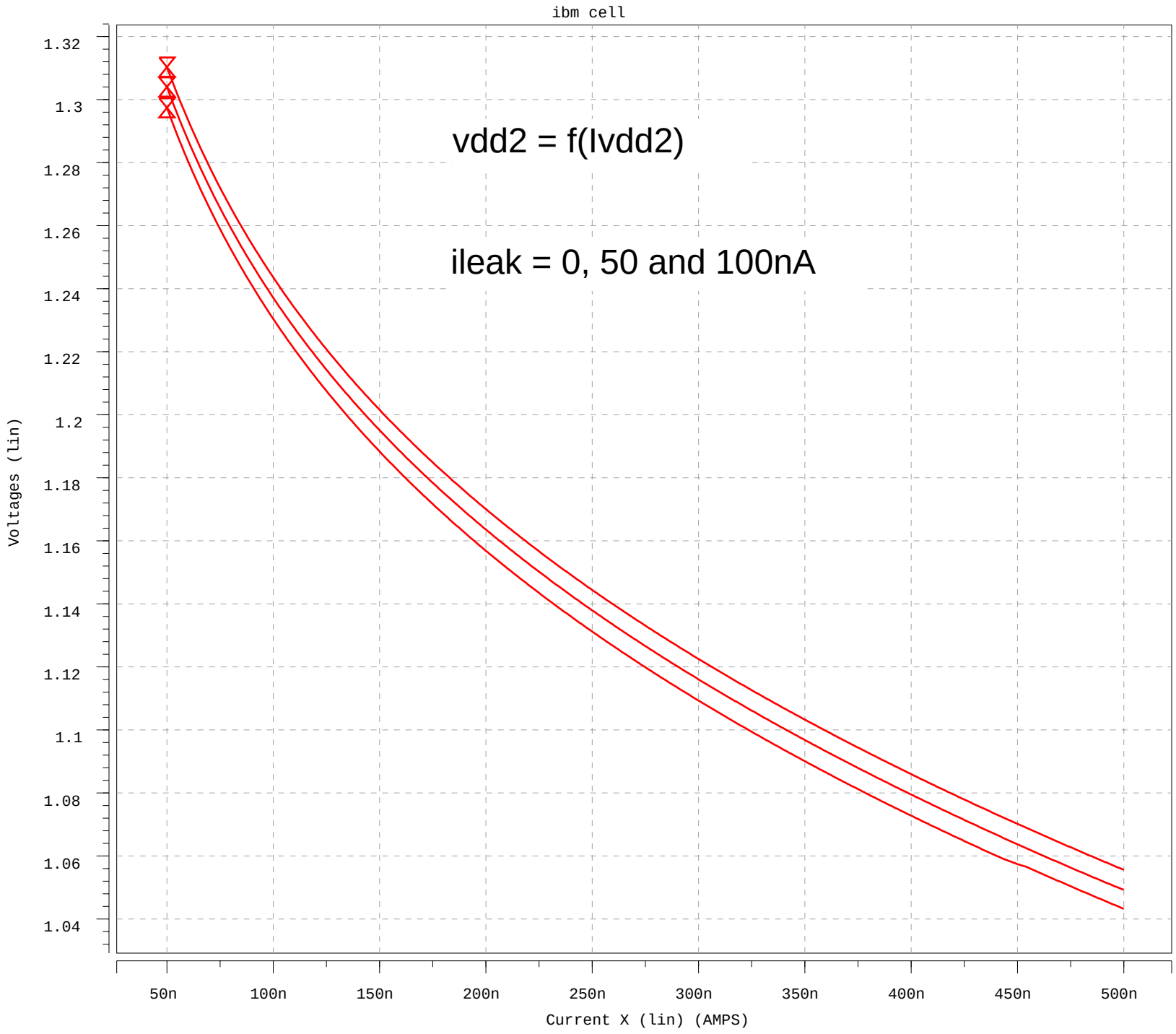
input of the preamp

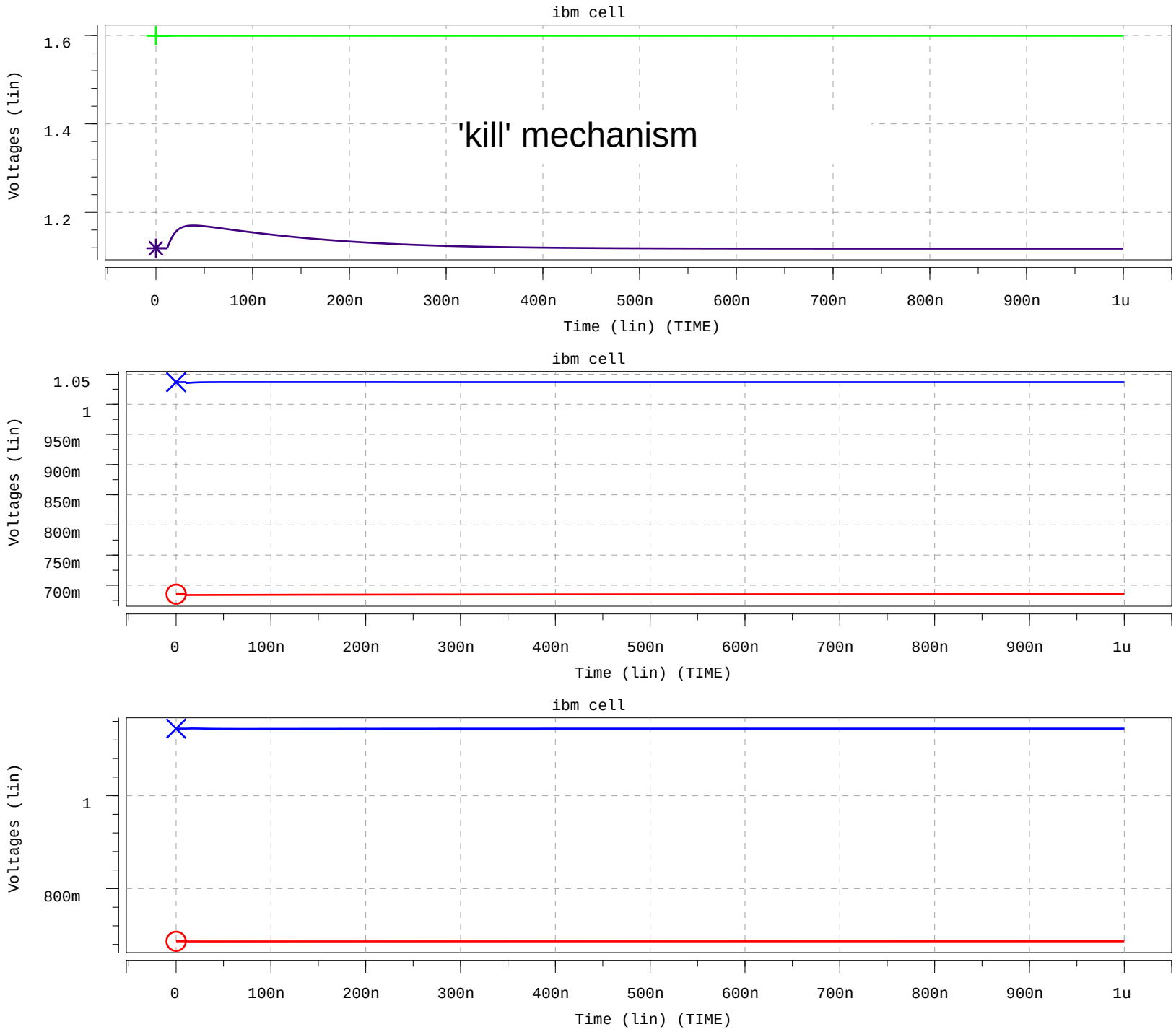


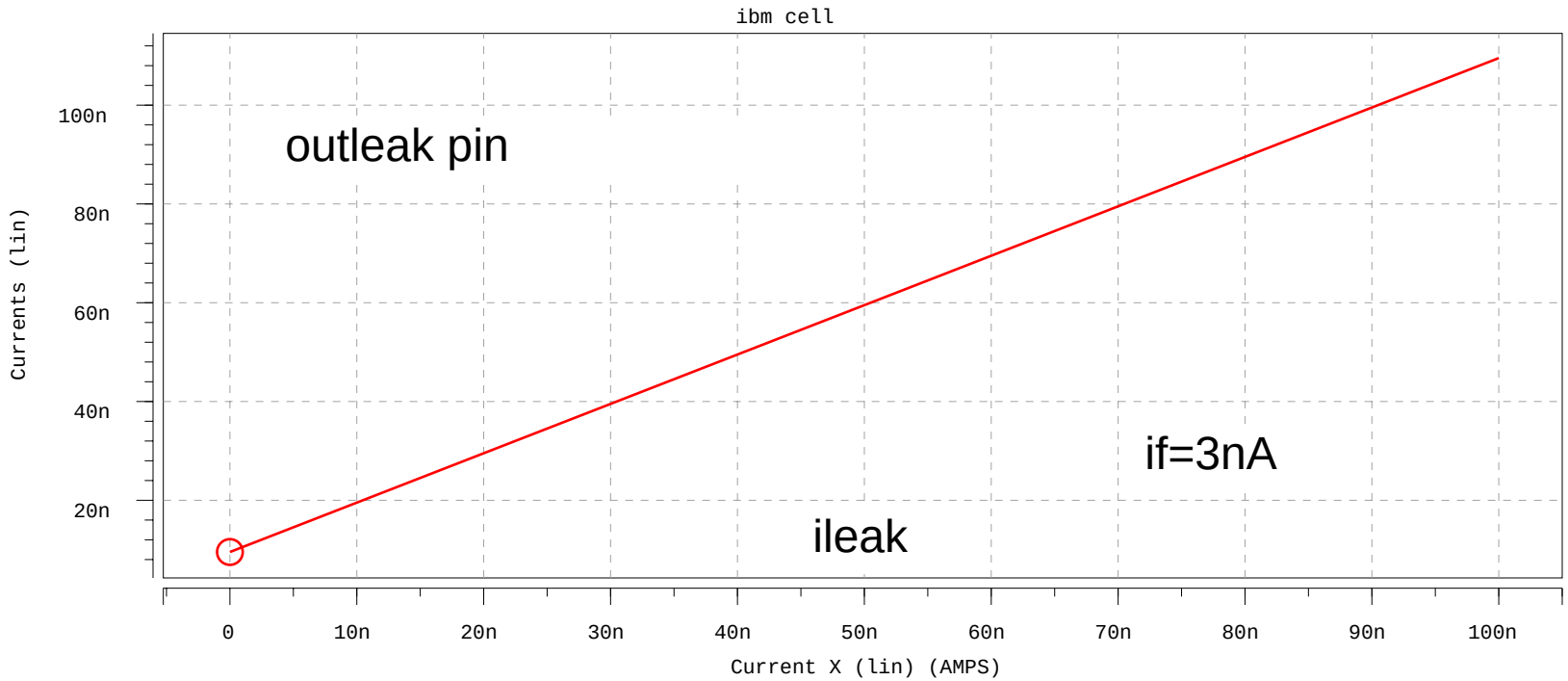

ibm cell
If=10nA
Voltages (lin)
1.6
1.5
1.4
1.3
1.2
1.1
0
50n
100n
150n
200n
250n
300n
350n
400n
450n
500n
Time (lin) (TIME)

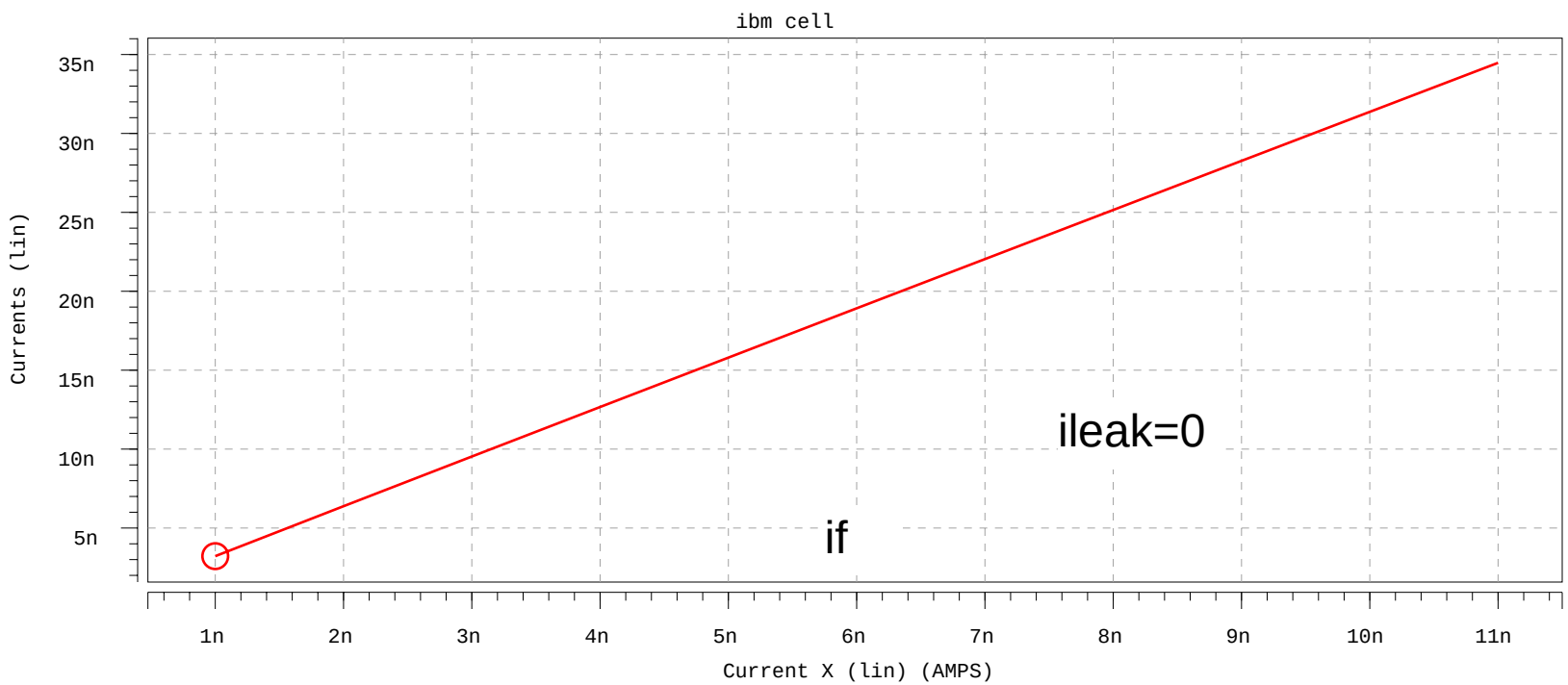

ibm cell
If=1nA
Voltages (lin)
1.6
1.4
1.2
1
0
50n
100n
150n
200n
250n
300n
350n
400n
450n
500n
Time (lin) (TIME)

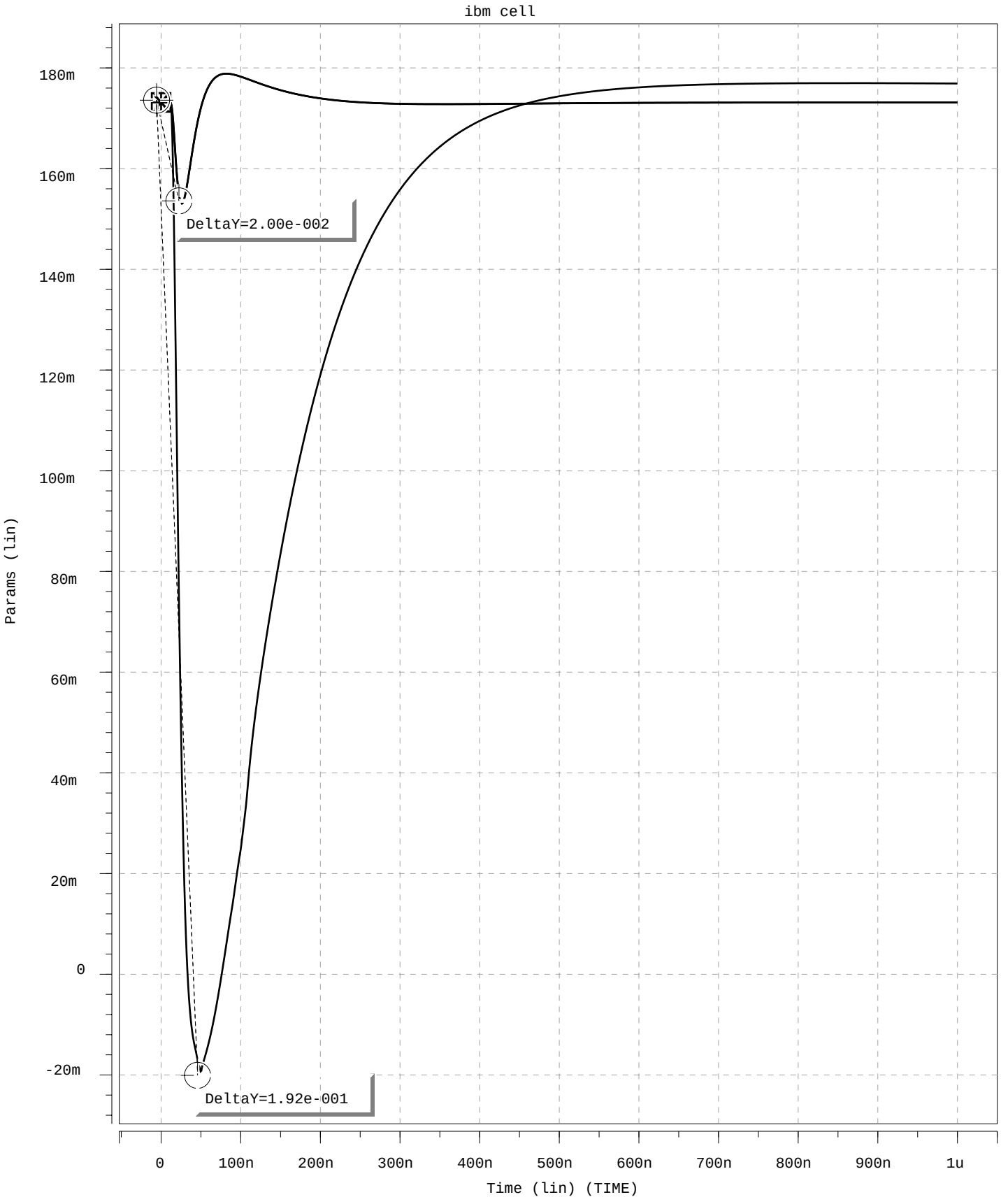

ibm cell
vdd2=1.05V
ileak = 100nA
Voltages (lin)
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
0
50n
100n
150n
200n
250n
300n
350n
400n
450n
500n
Time (lin) (TIME)


ibm cell
vdd2 = f(Ivdd2)
ileak = 0, 50 and 100nA
Voltages (lin)
1.32
1.3
1.28
1.26
1.24
1.22
1.2
1.18
1.16
1.14
1.12
1.1
1.08
1.06
1.04
50n
100n
150n
200n
250n
300n
350n
400n
450n
500n
Current X (lin) (AMPS)


ibm cell
'kill' mechanism
Voltages (lin)
1.6
1.4
1.2
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)
ibm cell
Voltages (lin)
1.05
1
950m
900m
850m
800m
750m
700m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)
ibm cell
Voltages (lin)
1
800m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

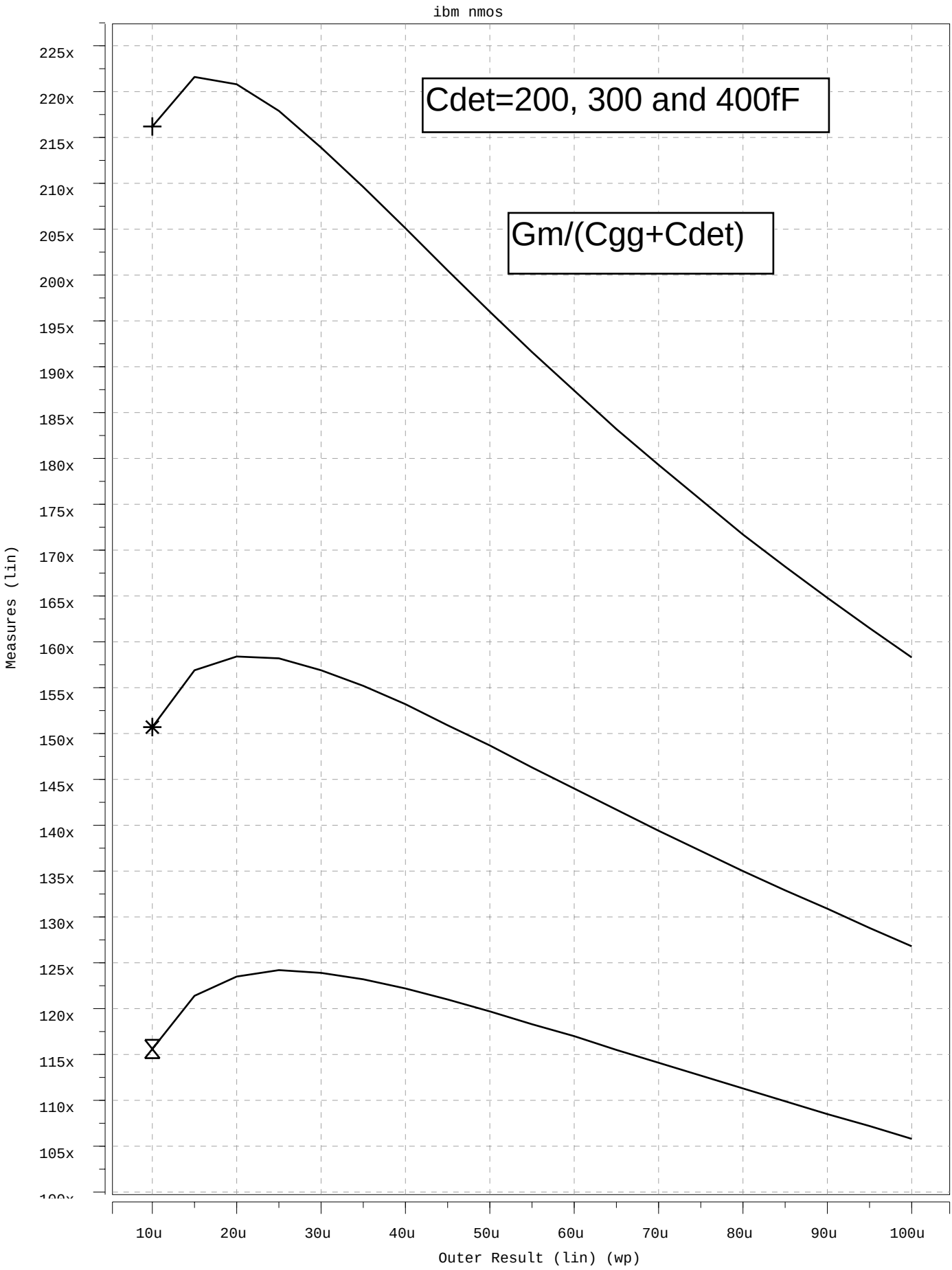

ibm cell
outleak pin
if=3nA
ileak
Currents (lin)
100n
80n
60n
40n
20n
0
10n
20n
30n
40n
50n
60n
70n
80n
90n
100n
Current X (lin) (AMPS)


ibm cell
ileak=0
if
Currents (lin)
35n
30n
25n
20n
15n
10n
5n
1n
2n
3n
4n
5n
6n
7n
8n
9n
10n
11n
Current X (lin) (AMPS)

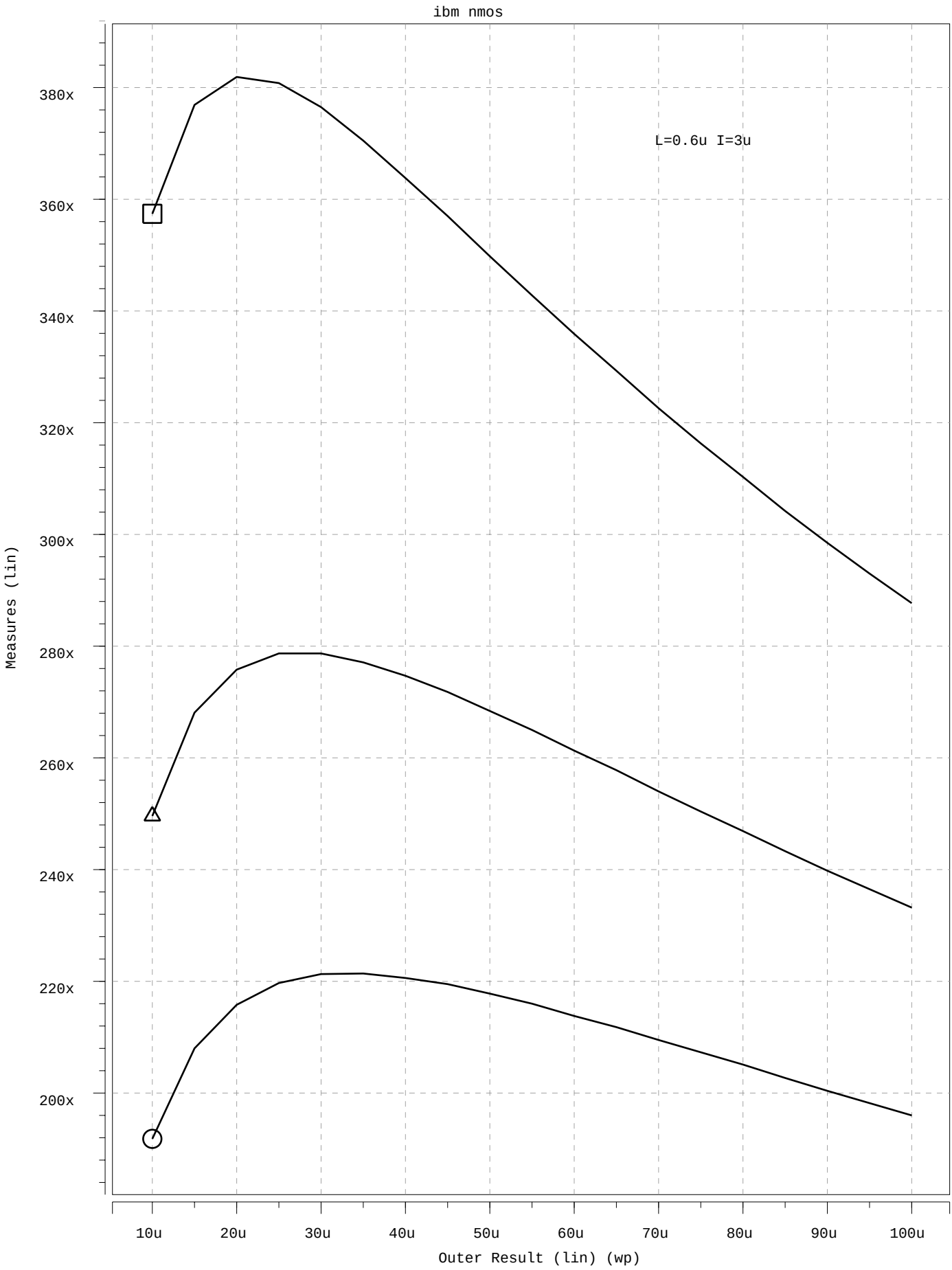

ibm cell
180m
160m
140m
120m
100m
80m
60m
40m
20m
0
-20m
Params (lin)
DeltaY=2.00e-002
DeltaY=1.92e-001
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

Choices

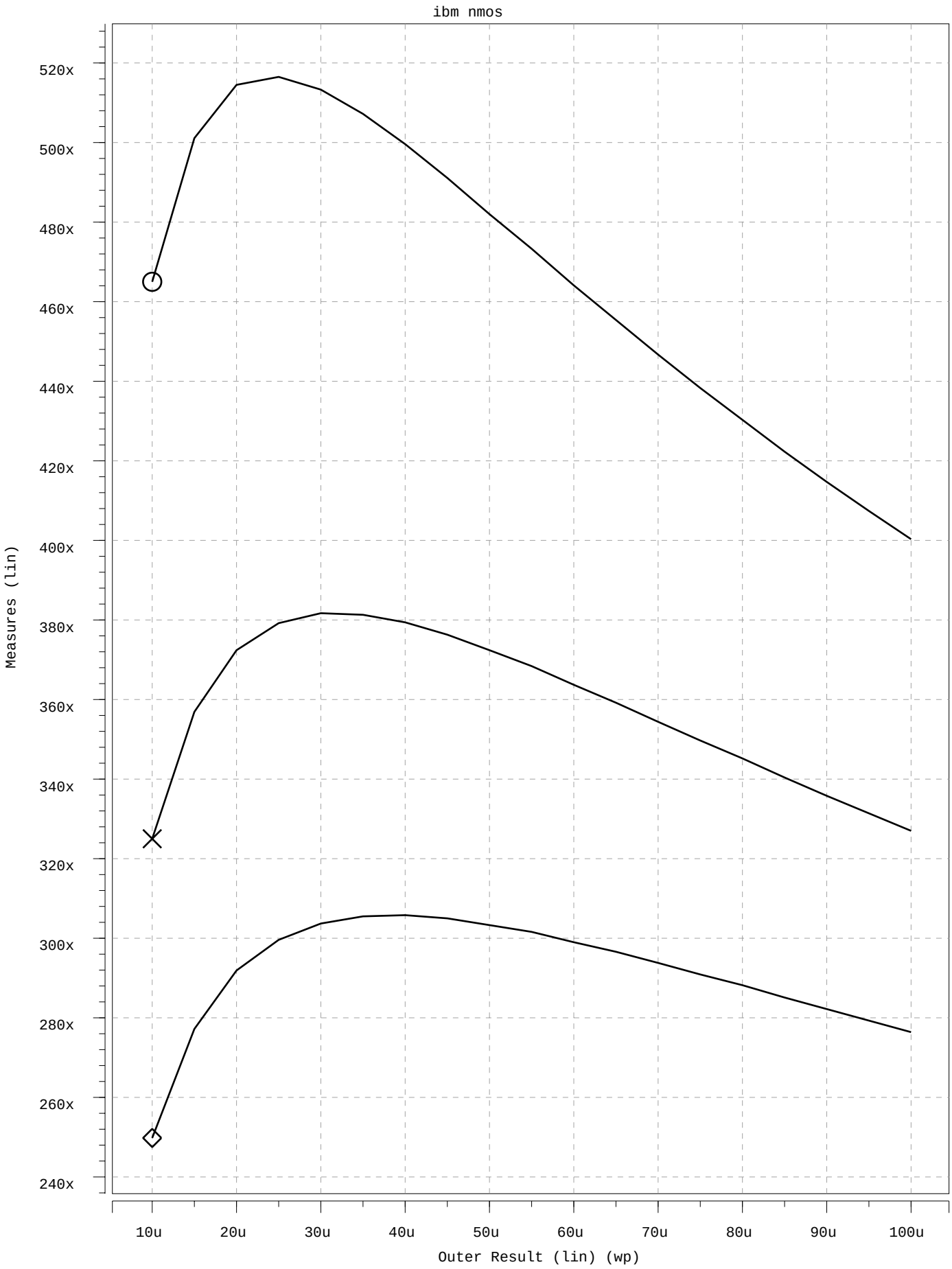
ID=3u


ibm nmos
Cdet=200, 300 and 400fF
Gm/(Cgg+Cdet)
Measures (lin)
225x
220x
215x
210x
205x
200x
195x
190x
185x
180x
175x
170x
165x
160x
155x
150x
145x
140x
135x
130x
125x
120x
115x
110x
105x
10u
20u
30u
40u
50u
60u
70u
80u
90u
100u
Outer Result (lin) (wp)

ID=6u


ibm nmos
L=0.6u I=3u
380x
360x
340x
320x
300x
280x
260x
240x
220x
200x
Measures (lin)
10u
20u
30u
40u
50u
60u
70u
80u
90u
100u
Outer Result (lin) (wp)

ID=9u


ibm nmos
520x
500x
480x
460x
440x
420x
400x
380x
360x
340x
320x
300x
280x
260x
240x
Measures (lin)
10u
20u
30u
40u
50u
60u
70u
80u
90u
100u
Outer Result (lin) (wp)

Cgg+Cdet (fF)	Voltage Gain (V)	BW (MHz)	φ_{margin} (°)	t_{rise} (ns)	GBW (MHz)
75 + 0	5.36 (14.6dB)	115	42.8	3	614
75 + 100	12.5 (22dB)	57	65	6	714
75 + 200	19.6 (25.9dB)	37.5	73.9	9.3	736
75 + 300	26.8 (28.5dB)	27.7	78.5	12.6	742
75 + 400	33.9 (30.6dB)	22	81.2	16	744
75 + 500	41.1 (32.3dB)	18.1	83.1	19.3	744

pole/zero analysis

Without Cf

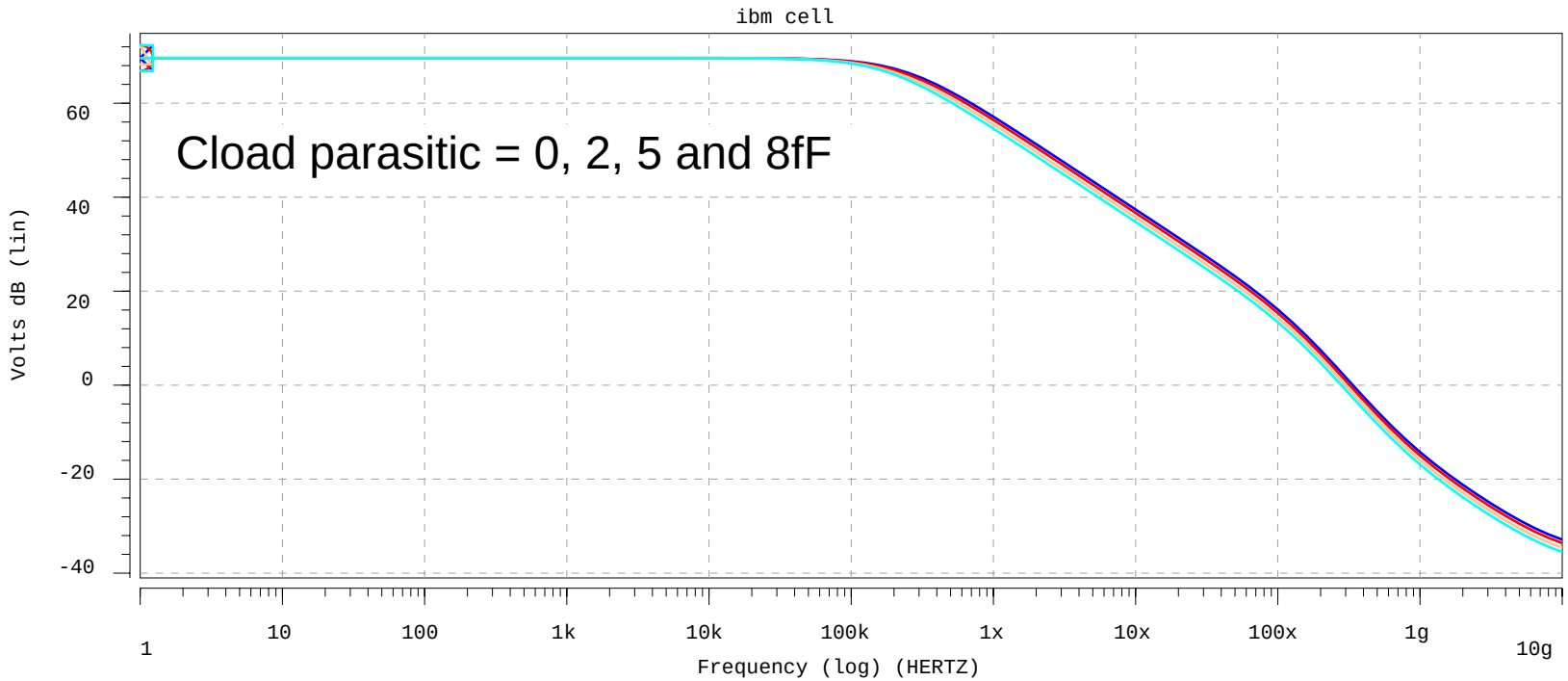
poles (rad/sec)		poles (hertz)	
real	imag	real	imag
0.	0.	0.	0.
-4.0058x	0.	-637.5472k	0.
-35.7425x	0.	-5.6886x	0.
-205.8966x	0.	-32.7695x	0.
-283.2085x	0.	-45.0740x	0.
-337.4896x	0.	-53.7131x	0.
-767.9106x	0.	-122.2168x	0.
-963.5963x	0.	-153.3611x	0.
-975.2796x	0.	-155.2206x	0.

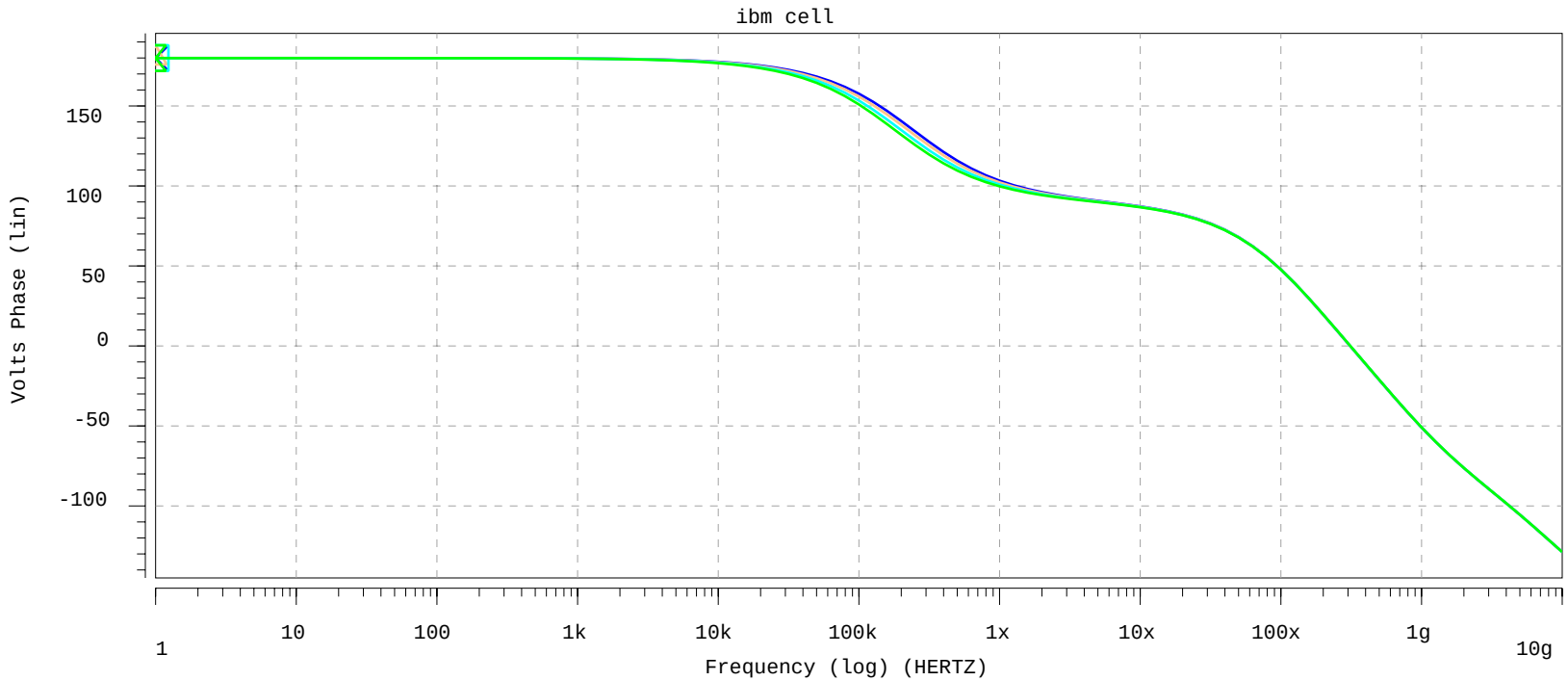
zeros (rad/sec)		zeros (hertz)	
real	imag	real	imag
0.	0.	0.	0.
-35.7996x	0.	-5.6977x	0.
-186.2815x	0.	-29.6476x	0.
-273.0753x	0.	-43.4613x	0.
-351.7196x	0.	-55.9779x	0.
-770.8642x	0.	-122.6868x	0.
-981.2933x	0.	-156.1777x	0.

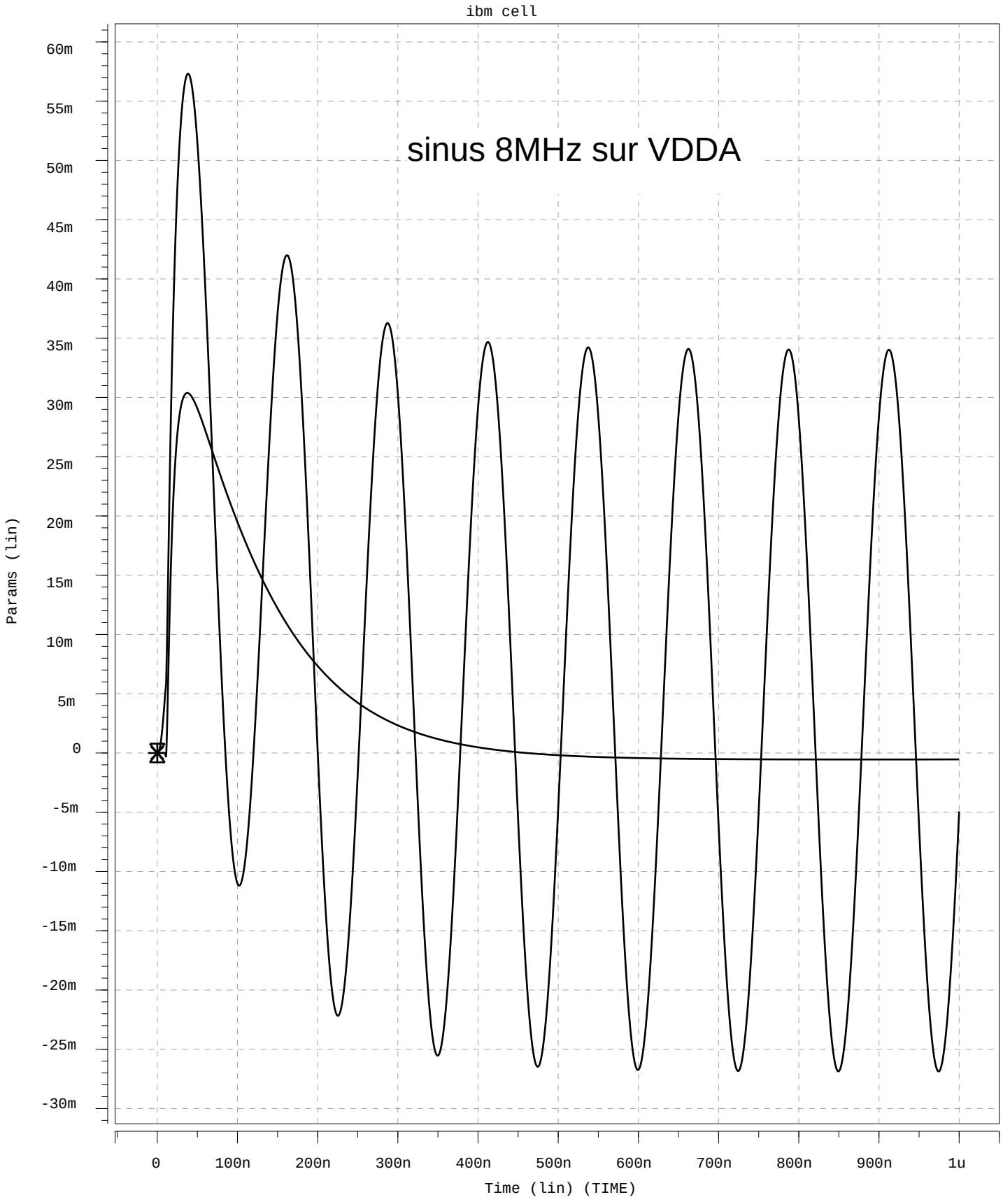
With Cf = 14fF

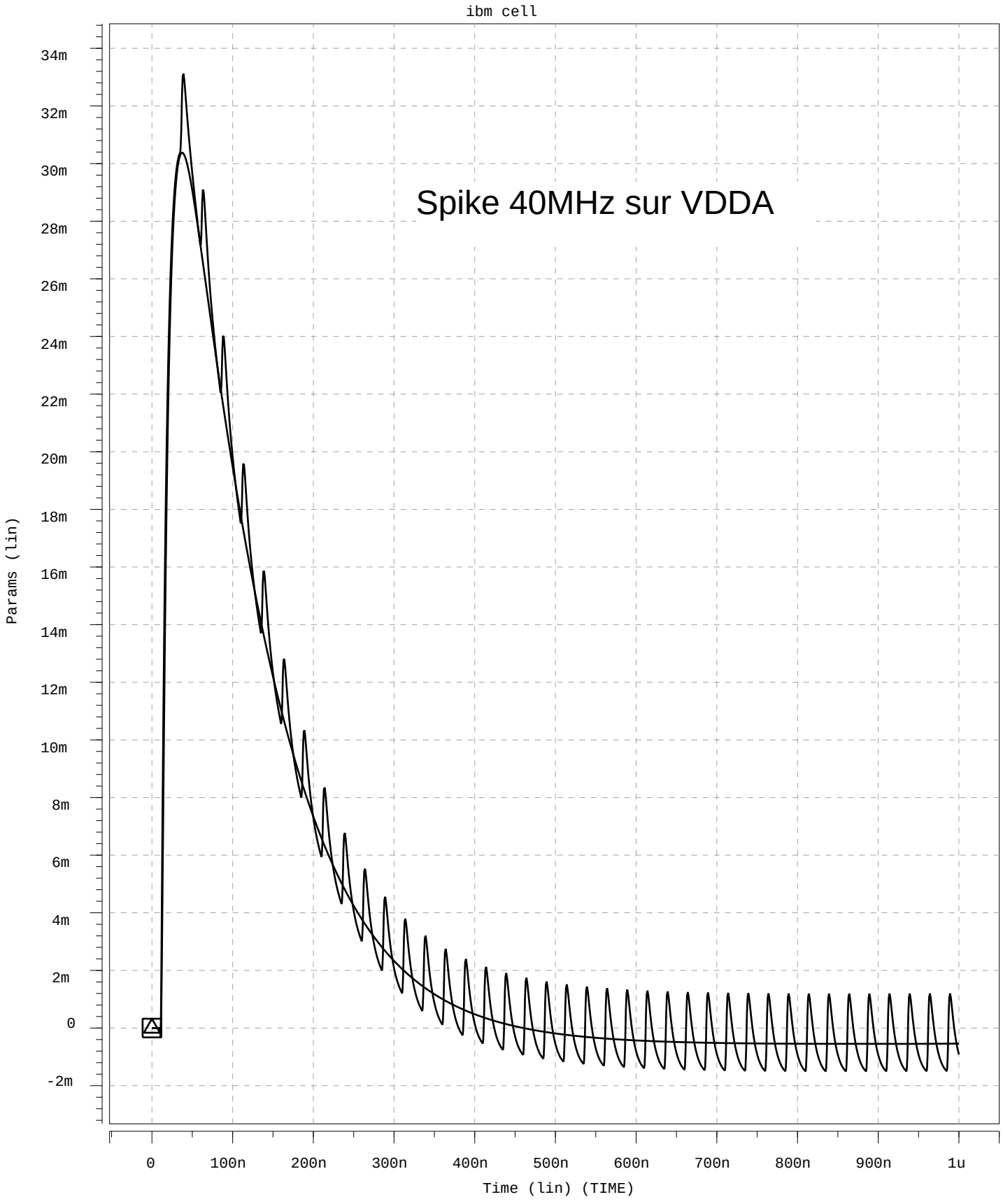
poles (rad/sec)		poles (hertz)	
real	imag	real	imag
0.	0.	0.	0.
-1.4740x	0.	-234.6018k	0.
-35.7798x	0.	-5.6945x	0.
-193.0655x	0.	-30.7273x	0.
-275.5790x	0.	-43.8598x	0.
-347.7063x	0.	-55.3392x	0.
-769.8383x	0.	-122.5236x	0.
-945.6457x	0.	-150.5042x	0.
-980.3425x	0.	-156.0264x	0.
-1.4455g	0.	-230.0550x	0.

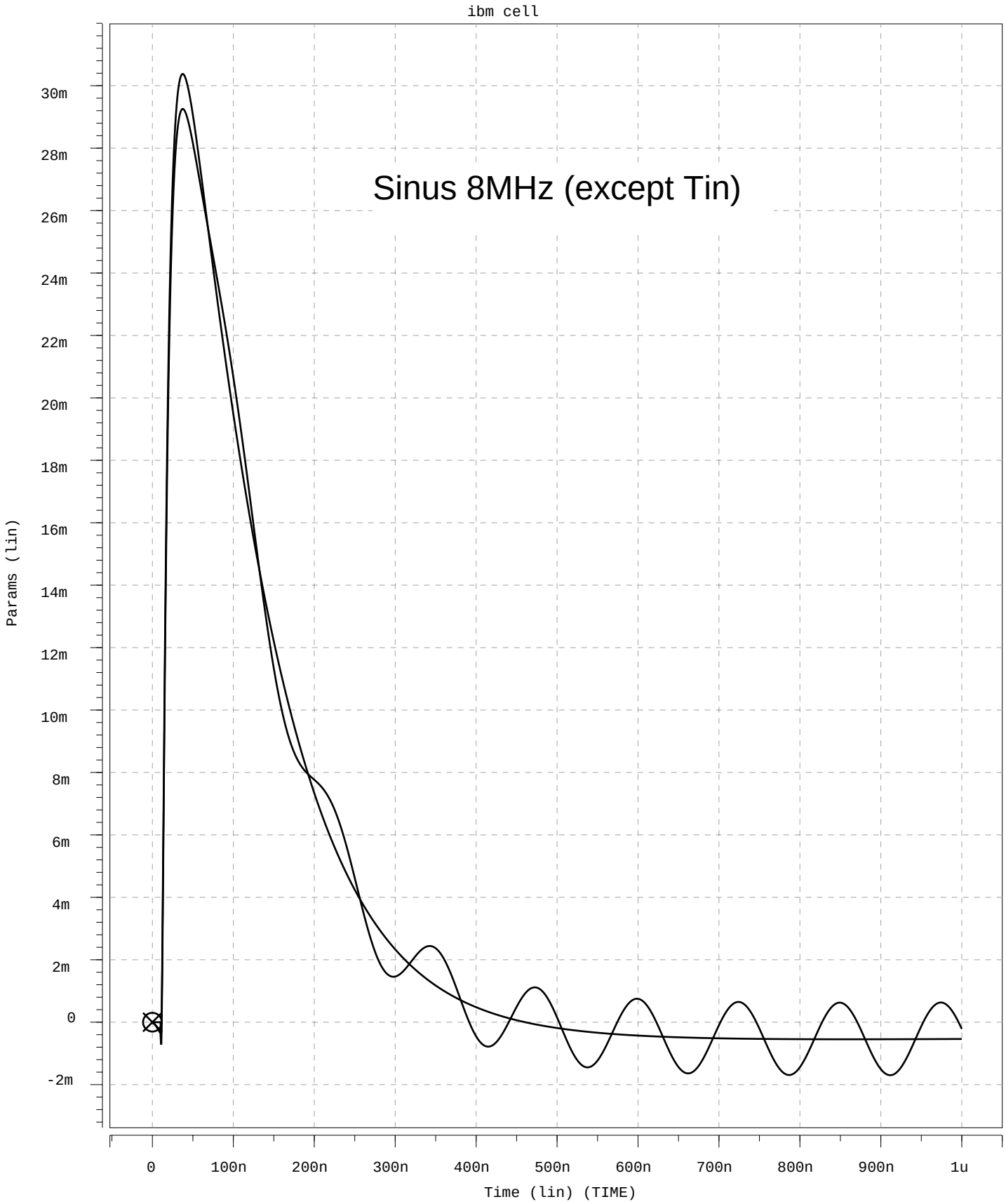
zeros (rad/sec)		zeros (hertz)	
real	imag	real	imag
0.	0.	0.	0.
-35.7996x	0.	-5.6977x	0.
-186.2815x	0.	-29.6476x	0.
-273.0753x	0.	-43.4613x	0.
-351.7196x	0.	-55.9779x	0.
-770.8642x	0.	-122.6868x	0.
-981.2933x	0.	-156.1777x	0.
-1.4679g	0.	-233.6277x	0.

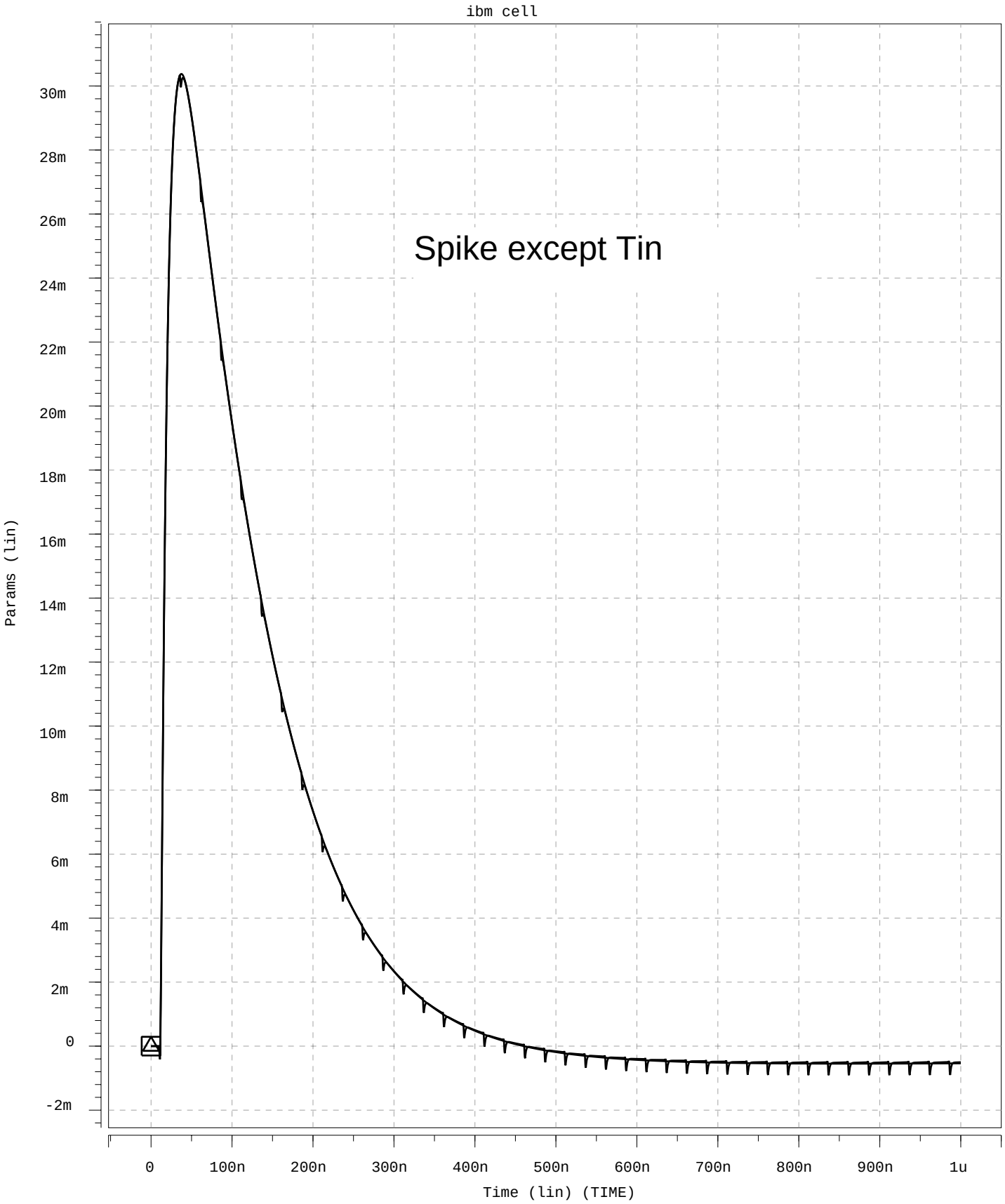

ibm cell
Cload parasitic = 0, 2, 5 and 8fF
Volts dB (lin)
60
40
20
0
-20
-40
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)

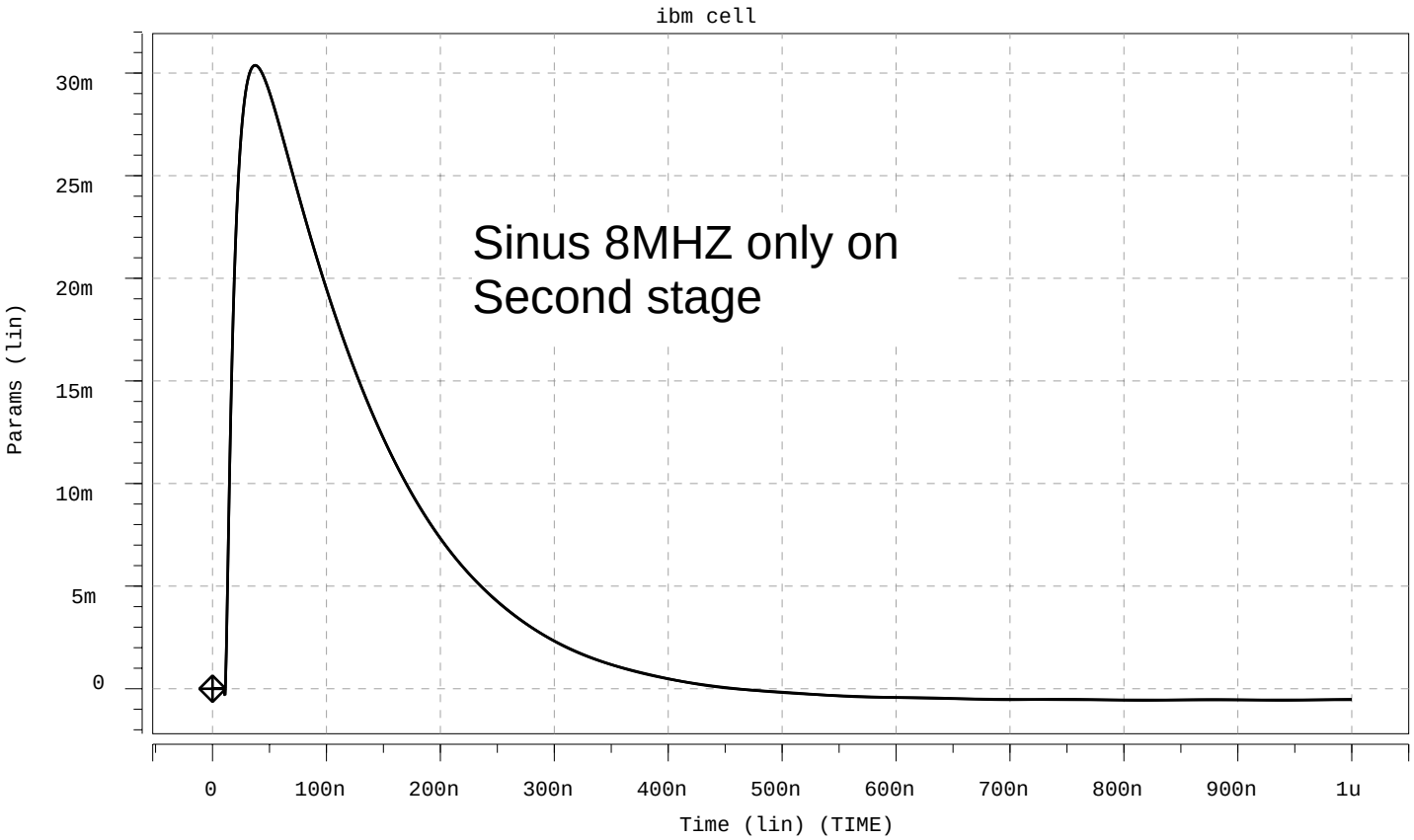

ibm cell
Volts Phase (lin)
150
100
50
0
-50
-100
1
10
100
1k
10k
100k
1x
10x
100x
1g
10g
Frequency (log) (HERTZ)

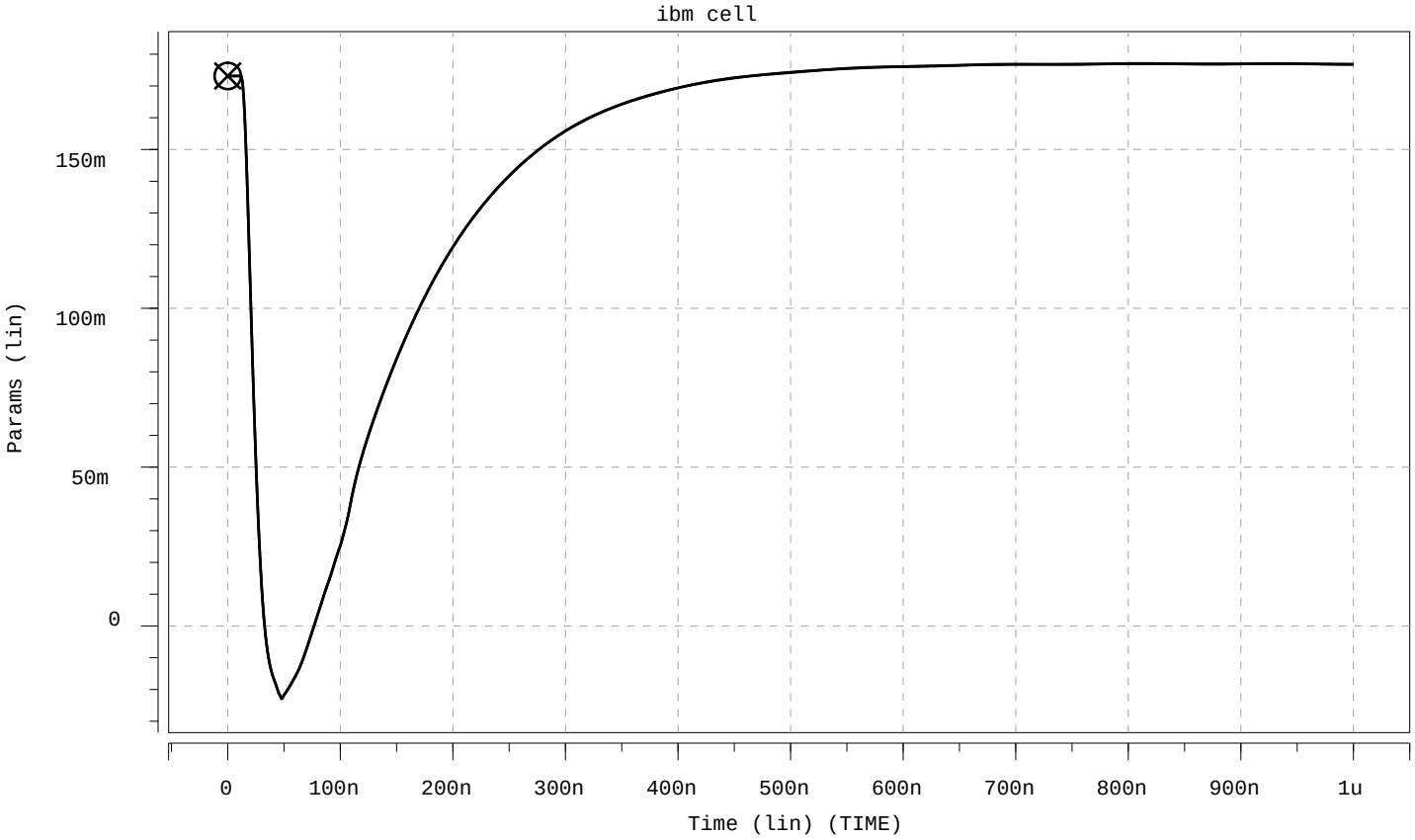

ibm cell
sinus 8MHz sur VDDA
Params (lin)
60m
55m
50m
45m
40m
35m
30m
25m
20m
15m
10m
5m
0
-5m
-10m
-15m
-20m
-25m
-30m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

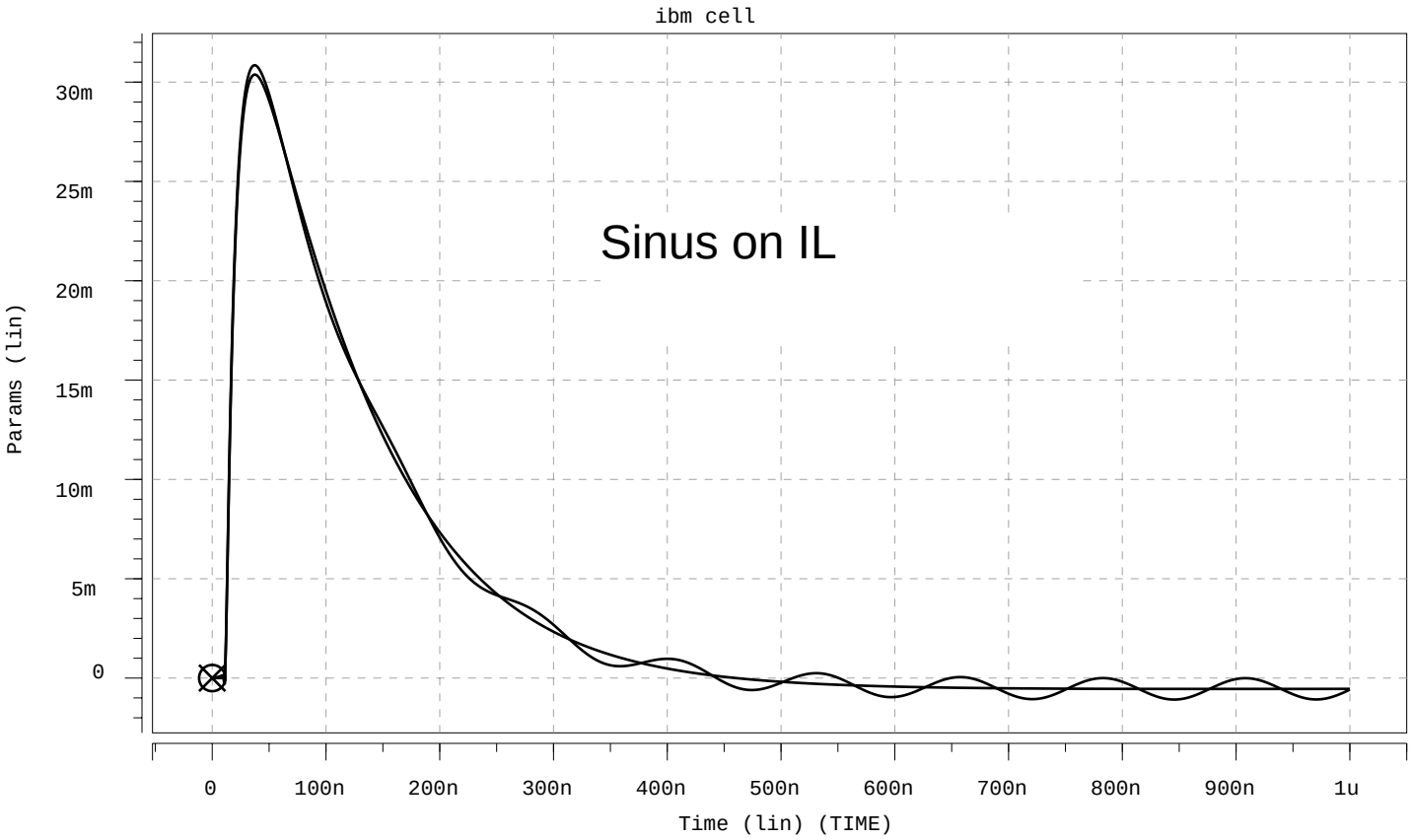

ibm cell
Spike 40MHz sur VDDA
Params (lin)
34m
32m
30m
28m
26m
24m
22m
20m
18m
16m
14m
12m
10m
8m
6m
4m
2m
0
-2m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

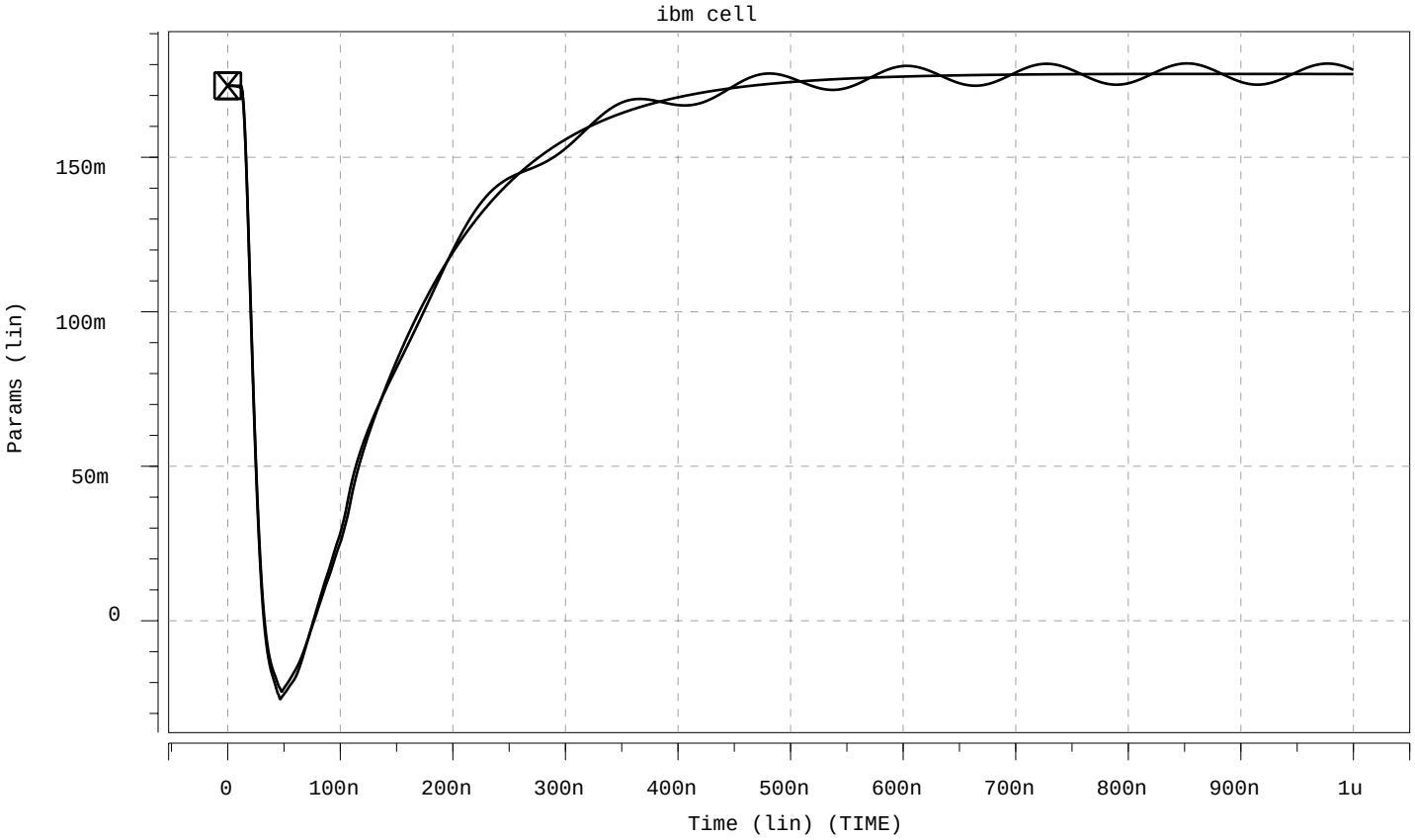

ibm cell
Sinus 8MHz (except Tin)
Params (lin)
30m
28m
26m
24m
22m
20m
18m
16m
14m
12m
10m
8m
6m
4m
2m
0
-2m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

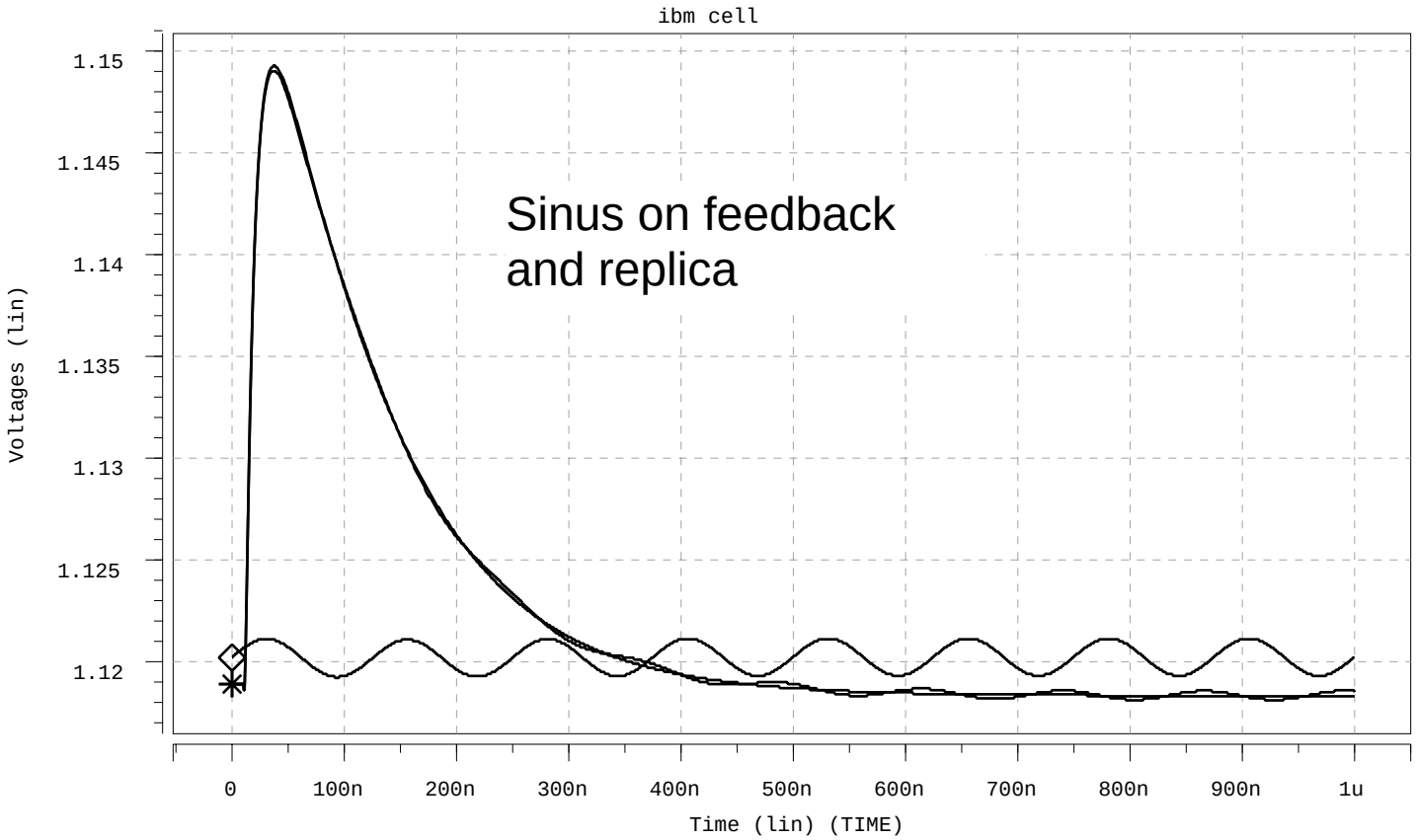

ibm cell
Spike except Tin
Params (lin)
30m
28m
26m
24m
22m
20m
18m
16m
14m
12m
10m
8m
6m
4m
2m
0
-2m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

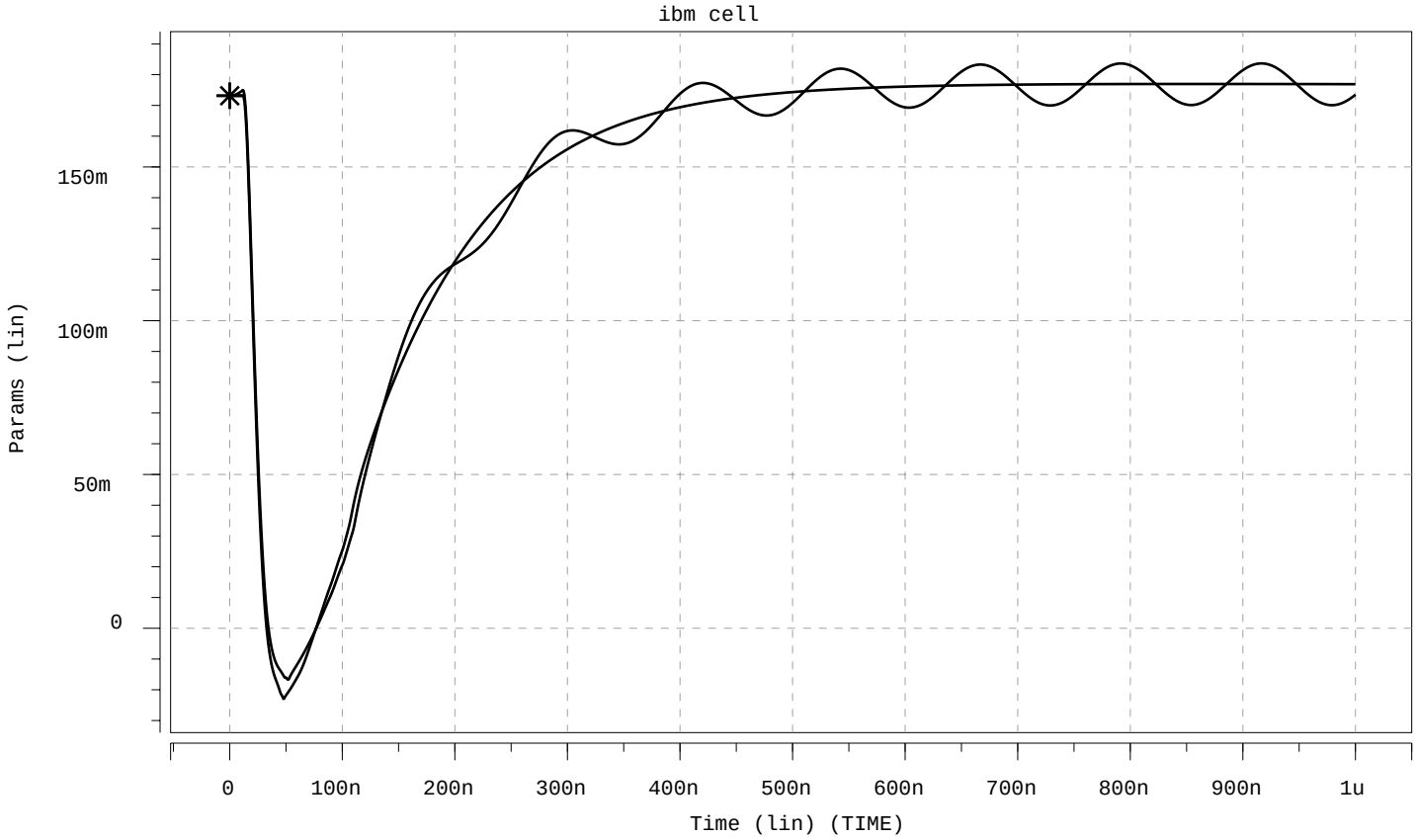

ibm cell
Sinus 8MHZ only on
Second stage
Params (lin)
30m
25m
20m
15m
10m
5m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

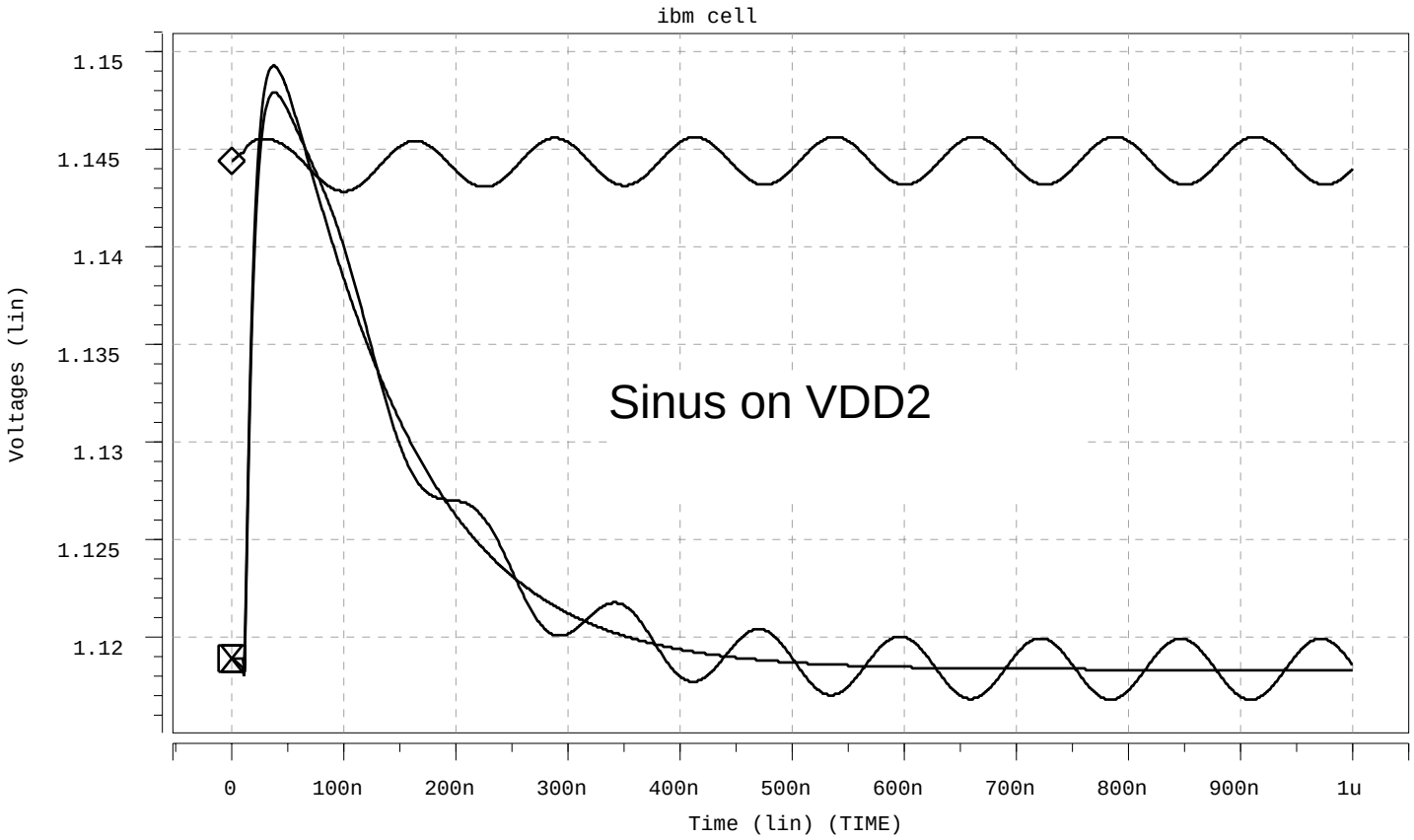

ibm cell
Params (lin)
150m
100m
50m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

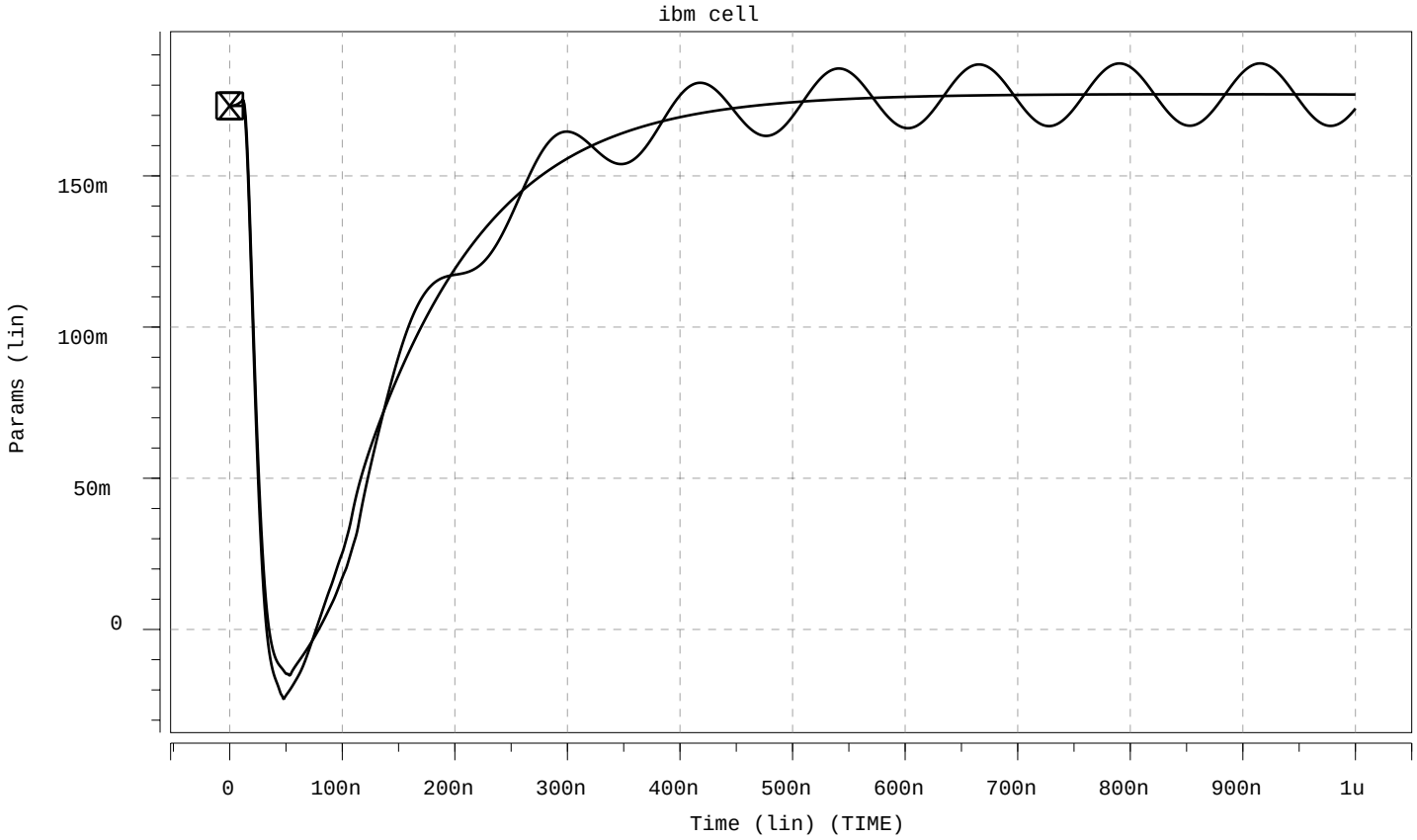

ibm cell
Sinus on IL
Params (lin)
30m
25m
20m
15m
10m
5m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

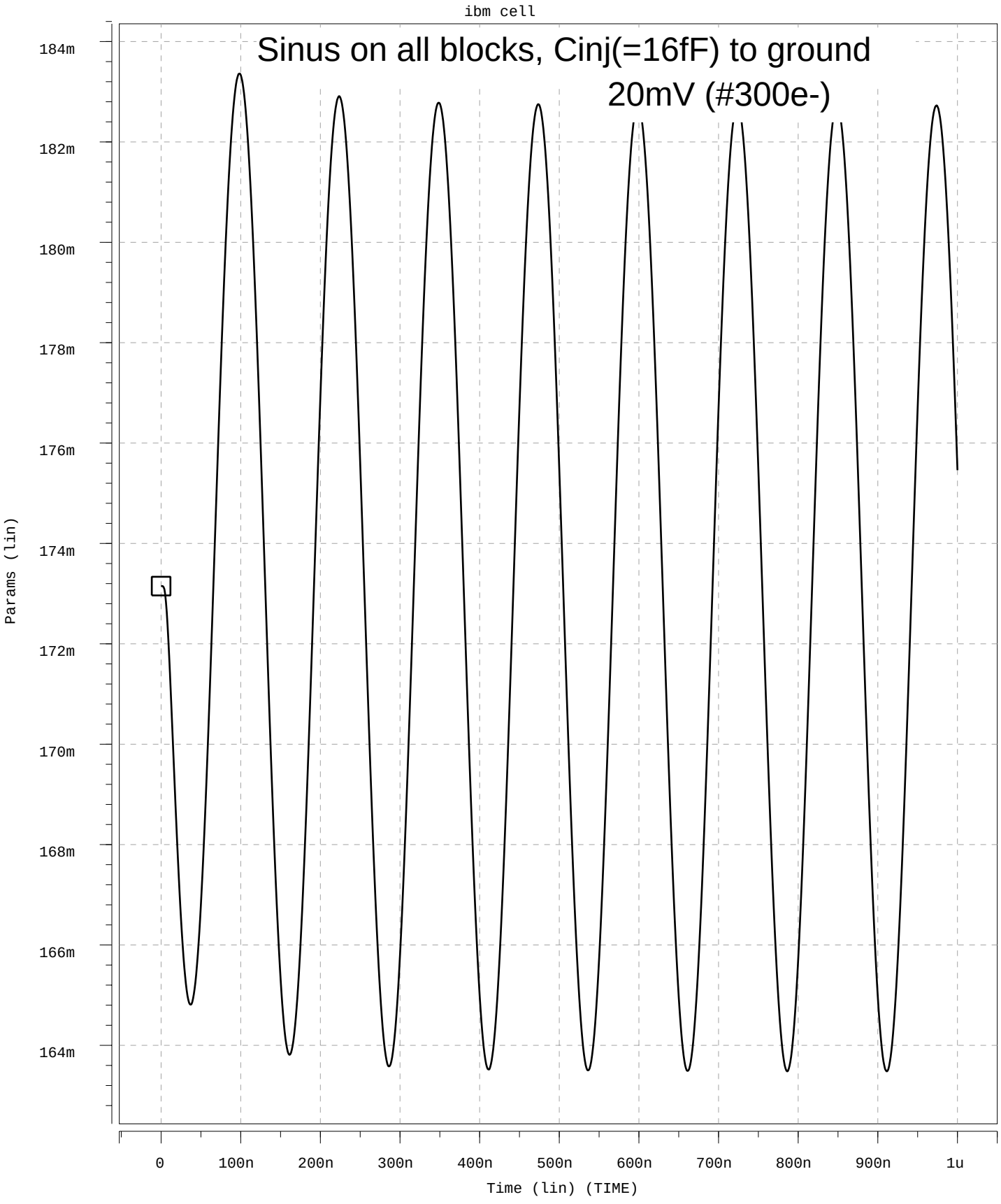

ibm cell
Params (lin)
150m
100m
50m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

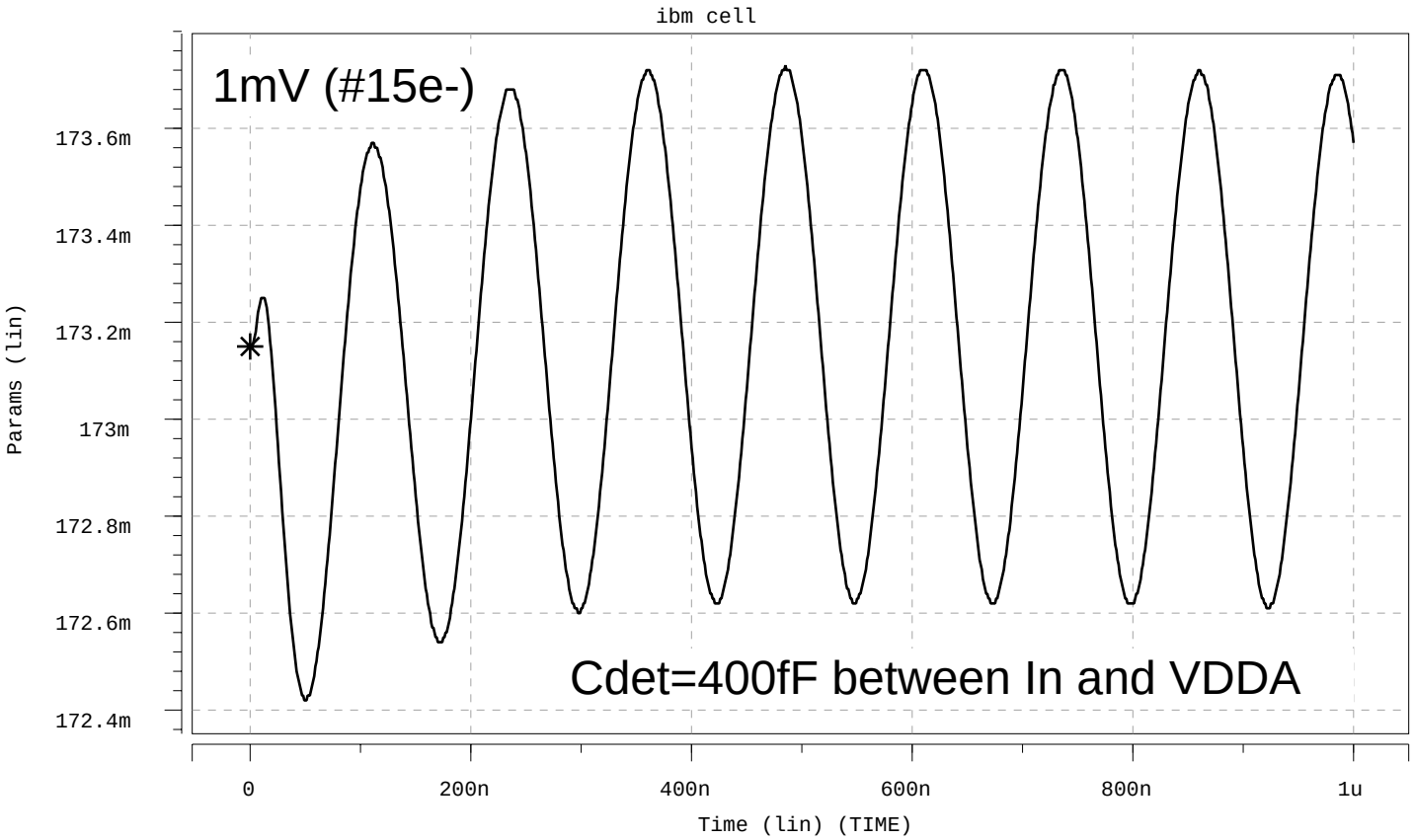

ibm cell
Sinus on feedback
and replica
Voltages (lin)
1.15
1.145
1.14
1.135
1.13
1.125
1.12
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

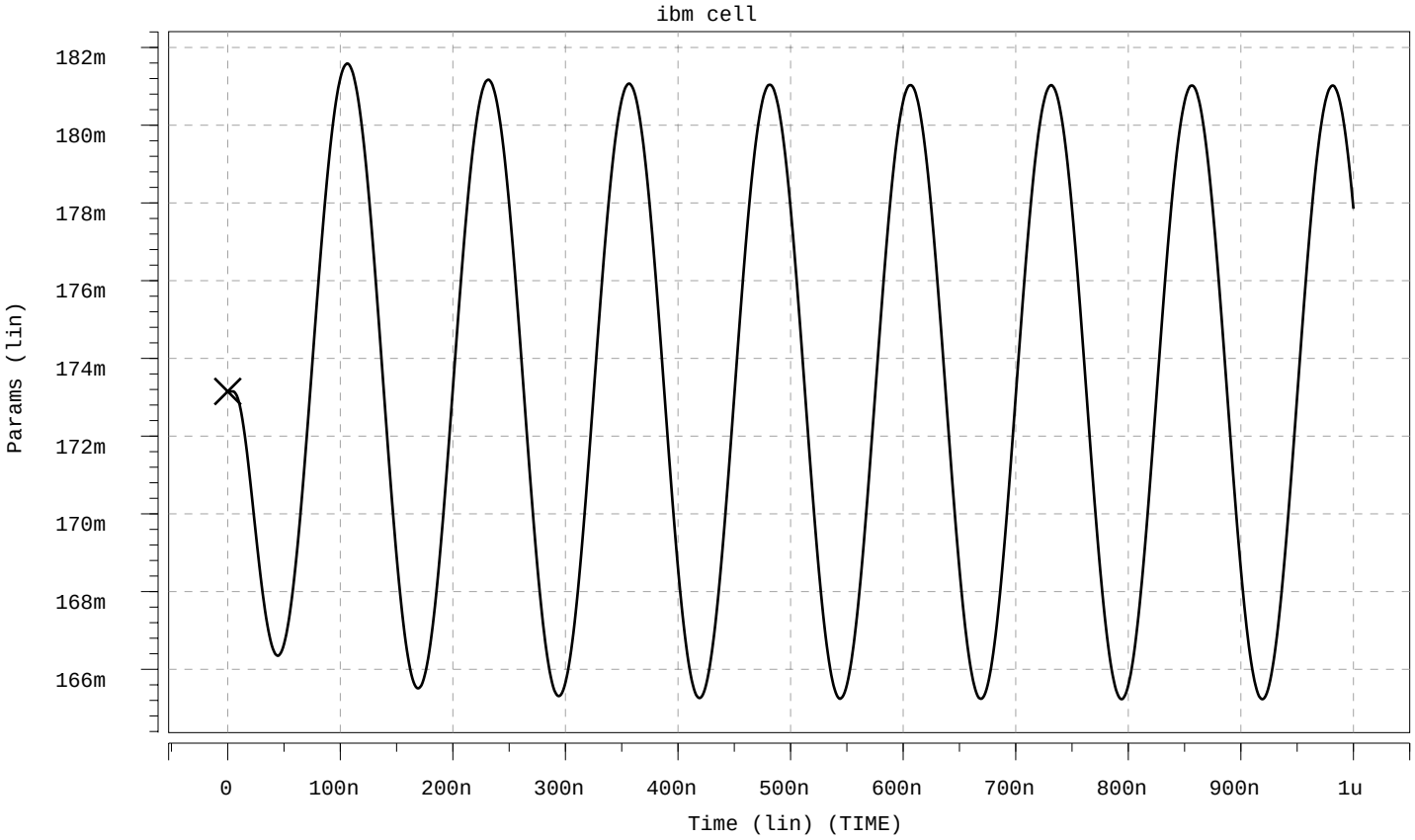

ibm cell
Params (lin)
150m
100m
50m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

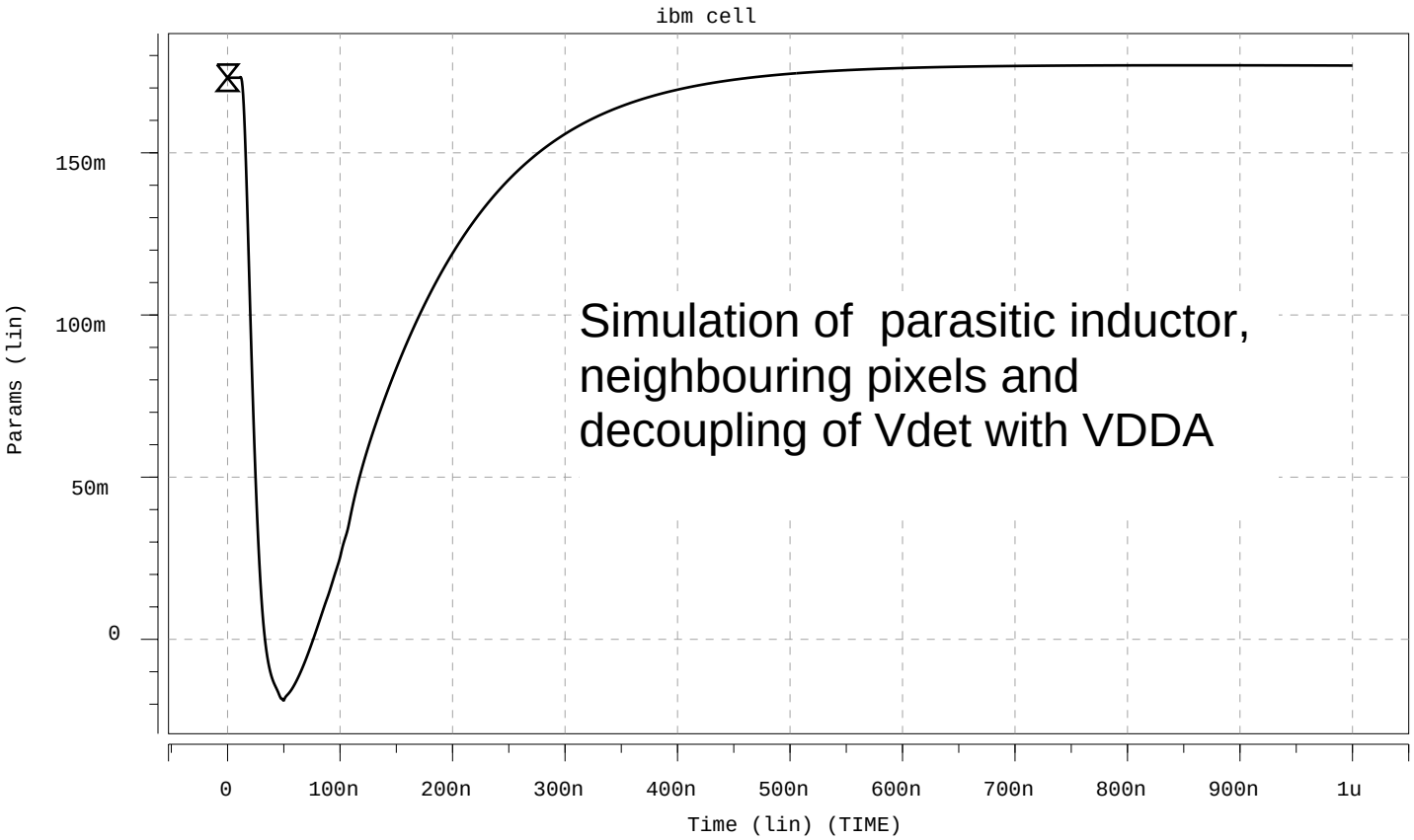

ibm cell
Sinus on VDD2
Voltages (lin)
1.15
1.145
1.14
1.135
1.13
1.125
1.12
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

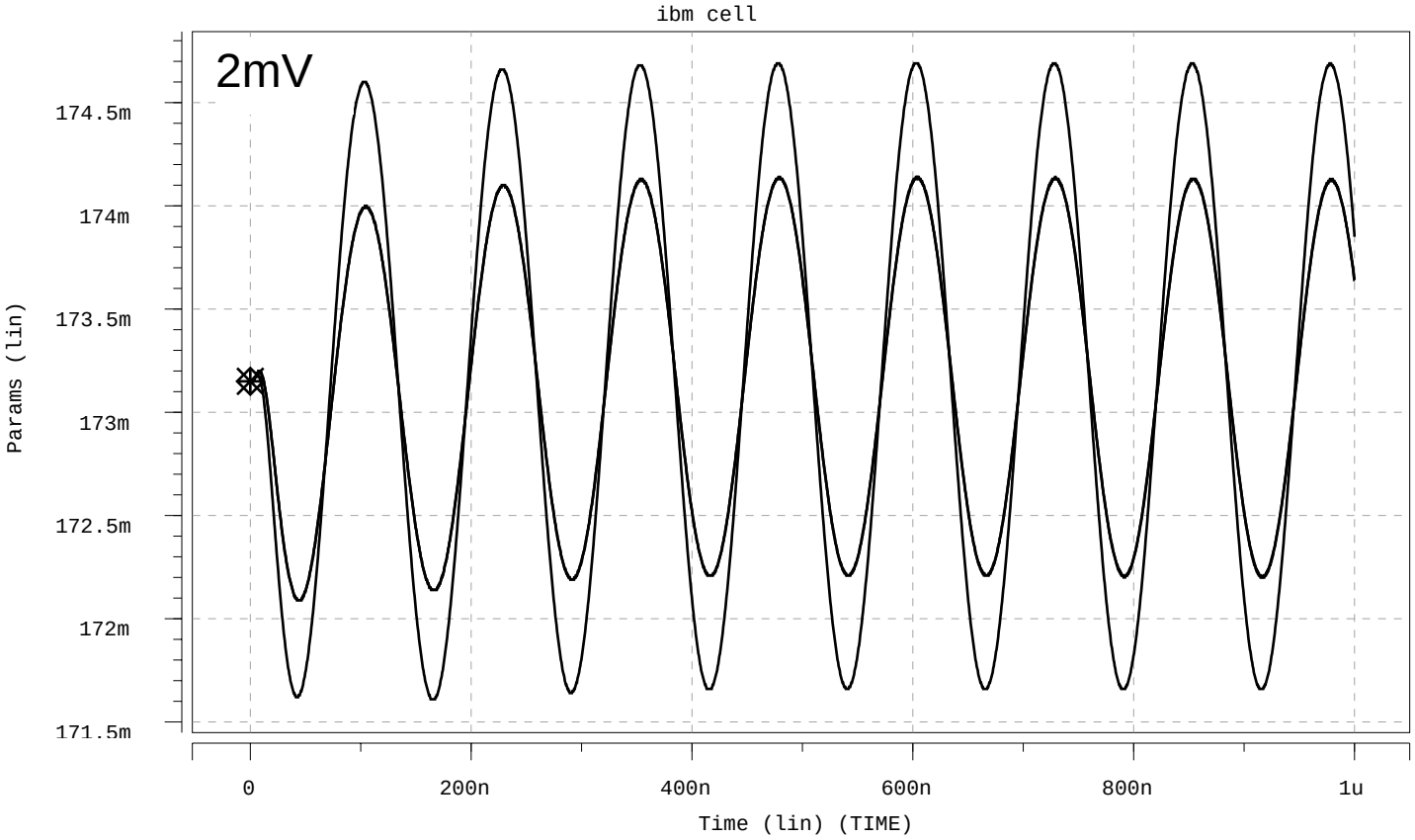

ibm cell
Params (lin)
150m
100m
50m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)


ibm cell
Sinus on all blocks, Cinj(=16fF) to ground
20mV (#300e-)
184m
182m
180m
178m
176m
174m
172m
170m
168m
166m
164m
Params (lin)
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

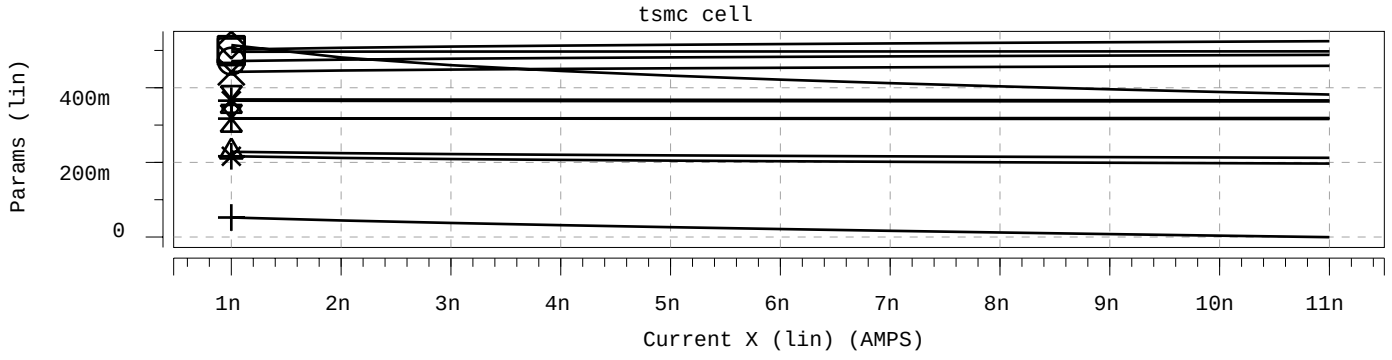

ibm cell
1mV (#15e-)
Cdet=400fF between In and VDDA
173.6m
173.4m
173.2m
173m
172.8m
172.6m
172.4m
Params (lin)
0
200n
400n
600n
800n
1u
Time (lin) (TIME)

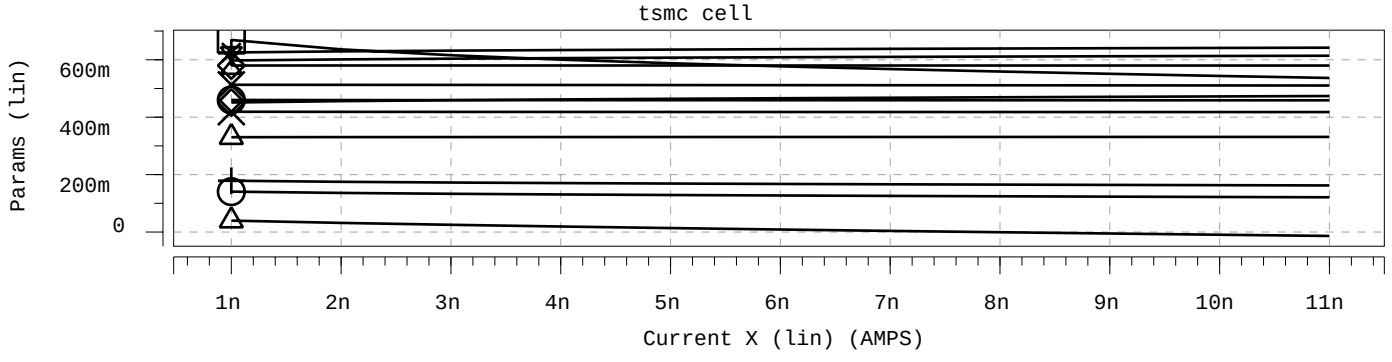

ibm cell
182m
180m
178m
176m
174m
172m
170m
168m
166m
Params (lin)
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

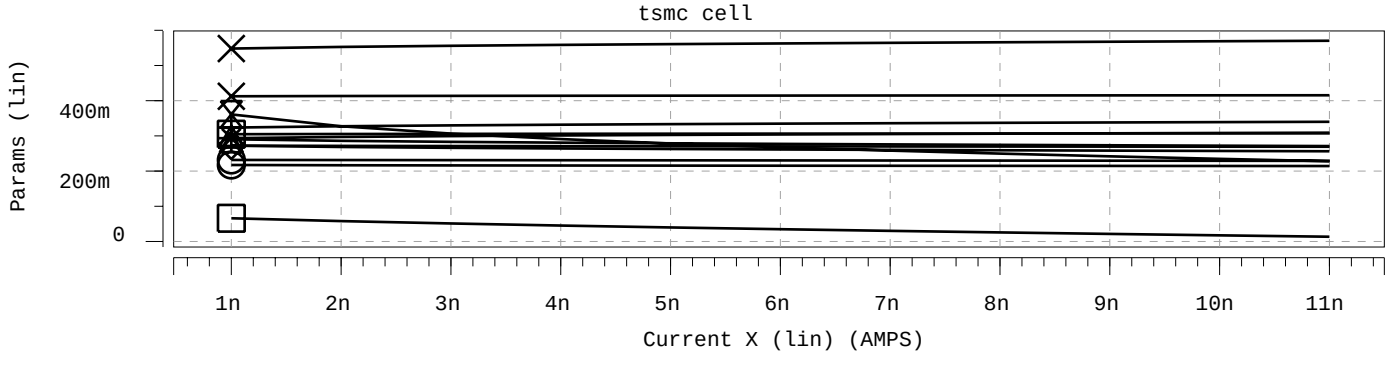

ibm cell
Simulation of parasitic inductor, neighbouring pixels and decoupling of Vdet with VDDA
Params (lin)
150m
100m
50m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

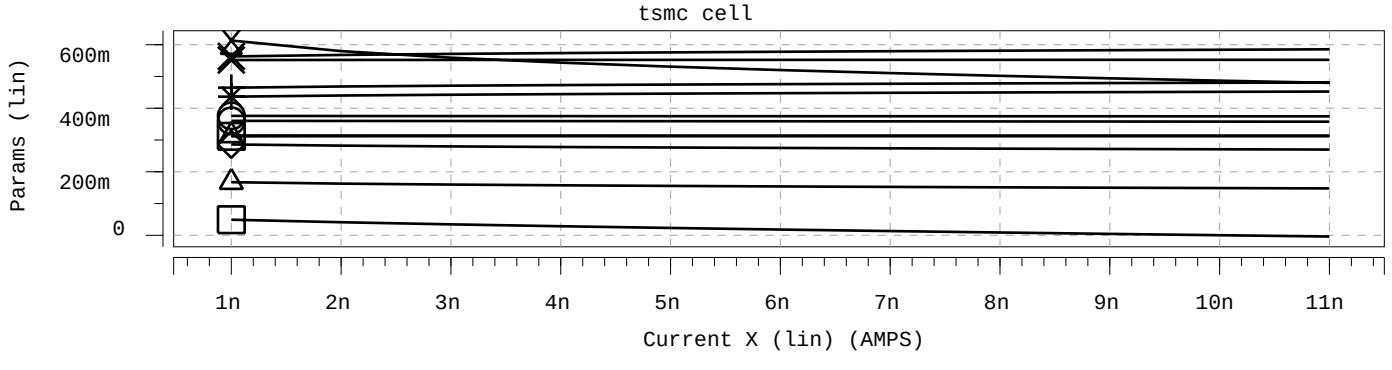

ibm cell
2mV
Params (lin)
174.5m
174m
173.5m
173m
172.5m
172m
171.5m
0
200n
400n
600n
800n
1u
Time (lin) (TIME)

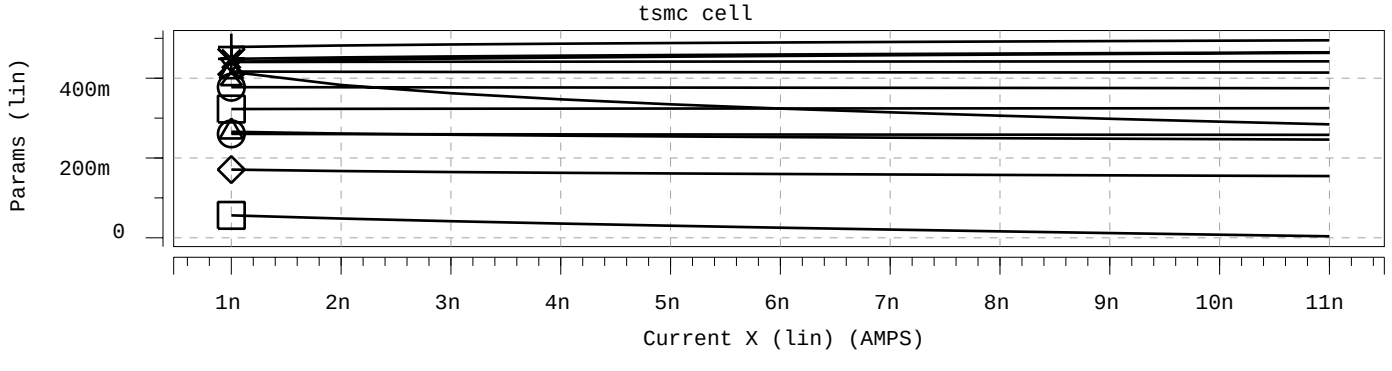
Corner Simulations

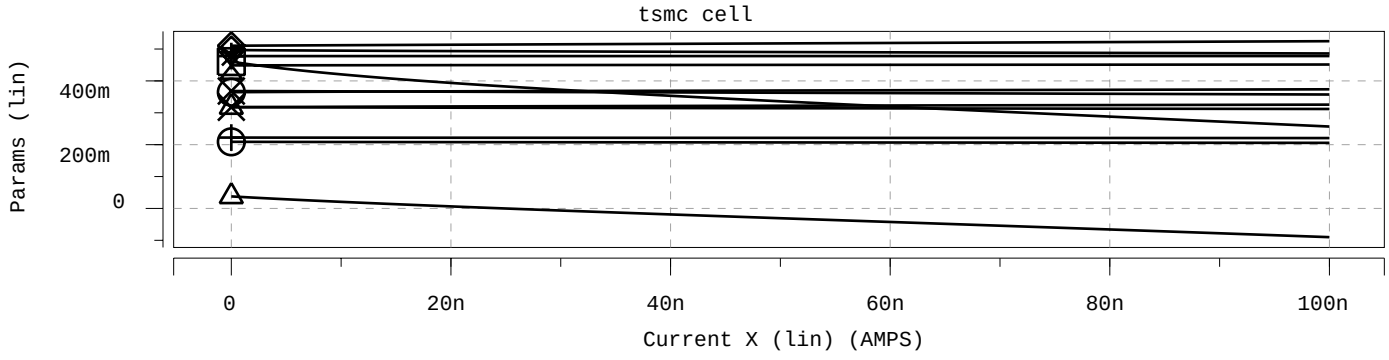

tsmc cell
Params (lin)
400m
200m
0
1n
2n
3n
4n
5n
6n
7n
8n
9n
10n
11n
Current X (lin) (AMPS)

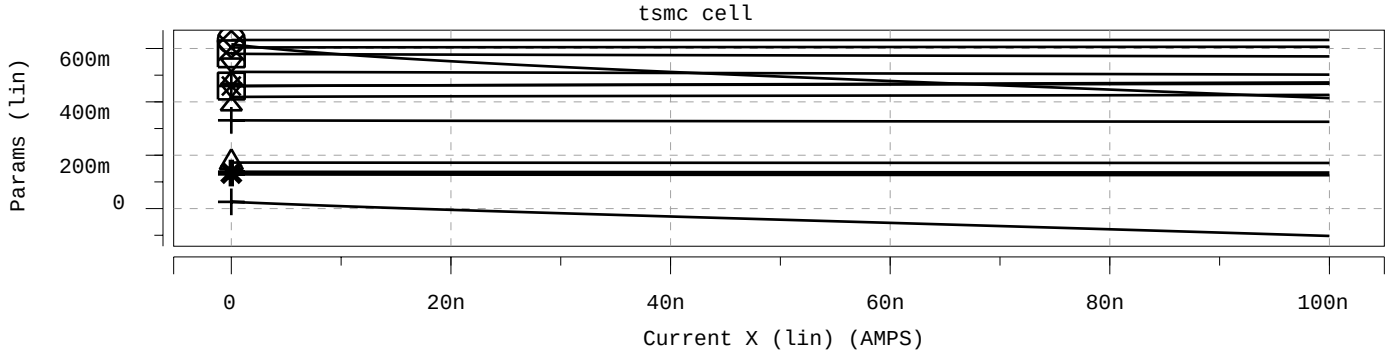

tsmc cell
Params (lin)
600m
400m
200m
0
1n
2n
3n
4n
5n
6n
7n
8n
9n
10n
11n
Current X (lin) (AMPS)

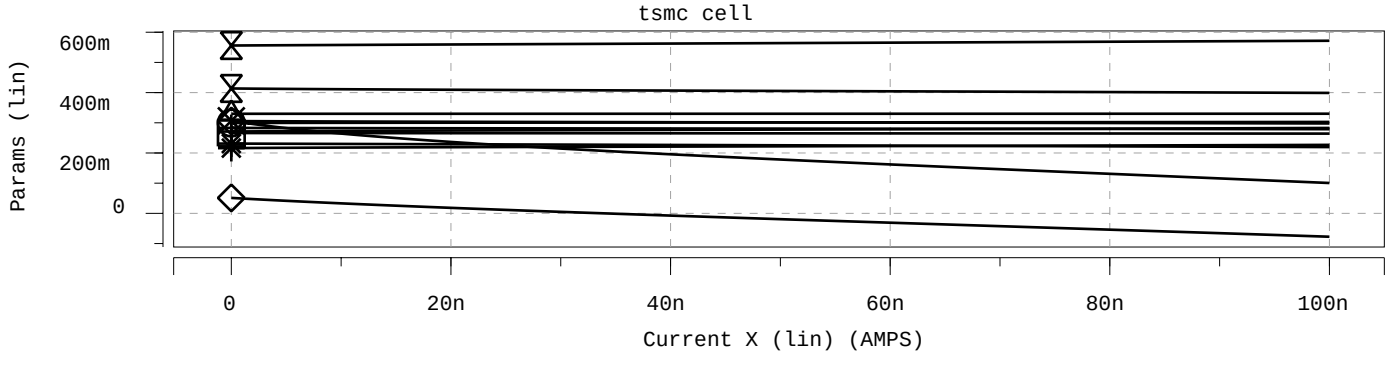

tsmc cell
Params (lin)
400m
200m
0
1n
2n
3n
4n
5n
6n
7n
8n
9n
10n
11n
Current X (lin) (AMPS)

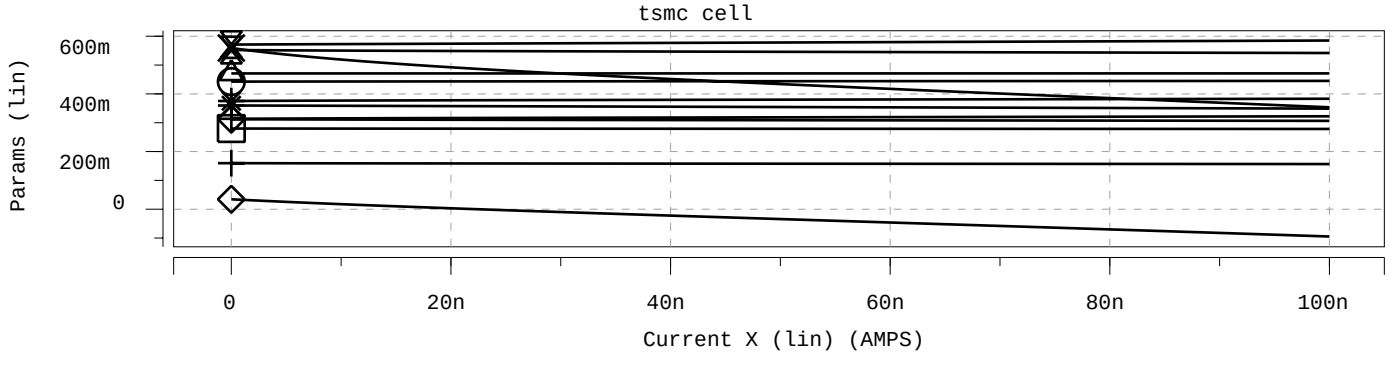

tsmc cell
Params (lin)
600m
400m
200m
0
1n
2n
3n
4n
5n
6n
7n
8n
9n
10n
11n
Current X (lin) (AMPS)

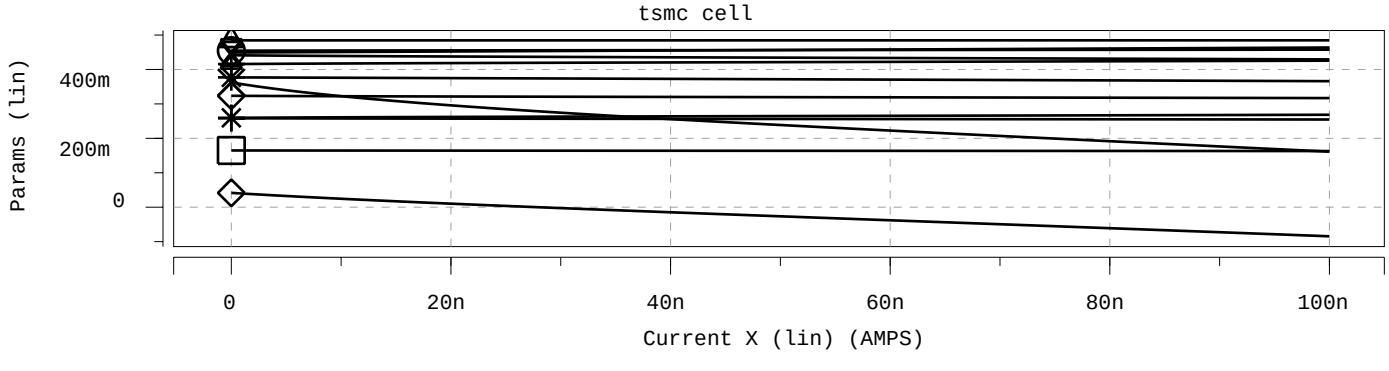

tsmc cell
Params (lin)
400m
200m
0
1n
2n
3n
4n
5n
6n
7n
8n
9n
10n
11n
Current X (lin) (AMPS)

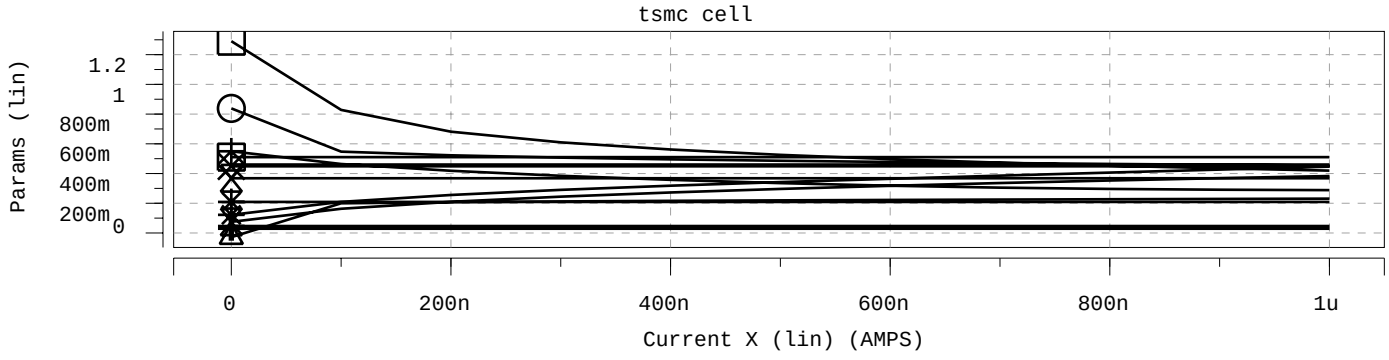

tsmc cell
Params (lin)
400m
200m
0
0
20n
40n
60n
80n
100n
Current X (lin) (AMPS)

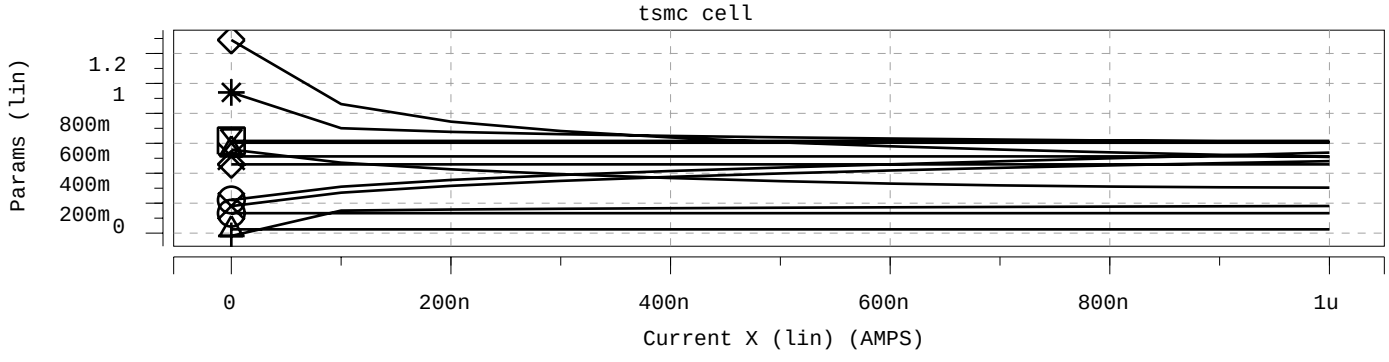

tsmc cell
Params (lin)
600m
400m
200m
0
0
20n
40n
60n
80n
100n
Current X (lin) (AMPS)

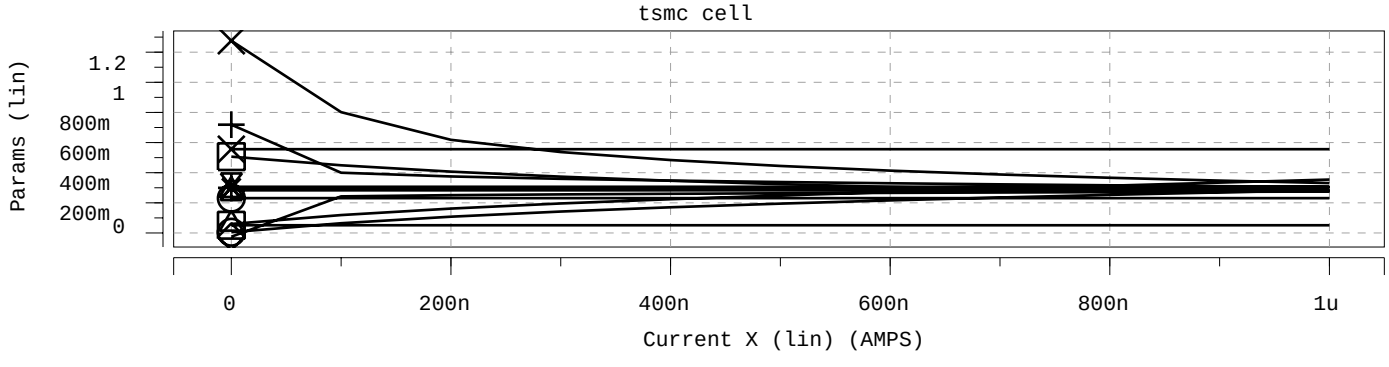

tsmc cell
Params (lin)
600m
400m
200m
0
0
20n
40n
60n
80n
100n
Current X (lin) (AMPS)

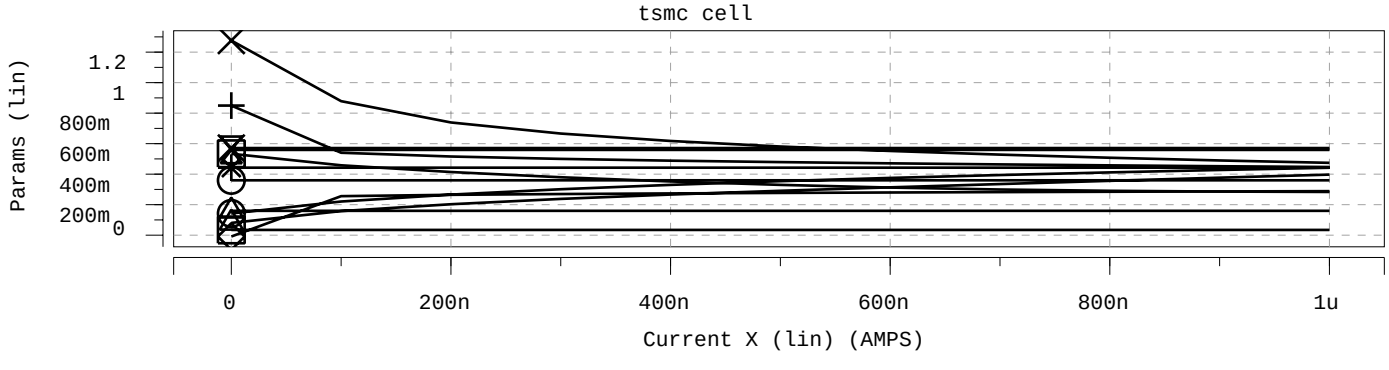

tsmc cell
Params (lin)
600m
400m
200m
0
0
20n
40n
60n
80n
100n
Current X (lin) (AMPS)

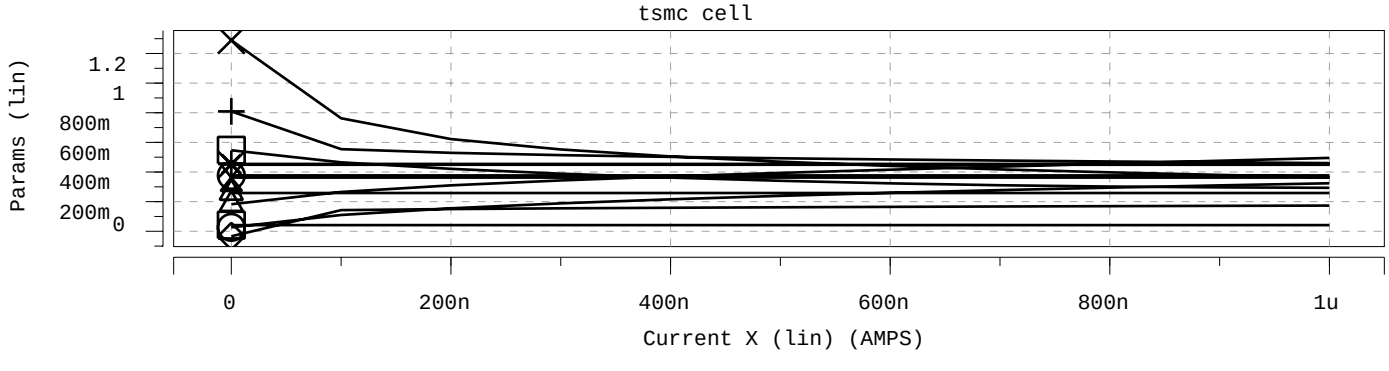

tsmc cell
Params (lin)
400m
200m
0
0
20n
40n
60n
80n
100n
Current X (lin) (AMPS)


tsmc cell
Params (lin)
1.2
1
800m
600m
400m
200m
0
0
200n
400n
600n
800n
1u
Current X (lin) (AMPS)

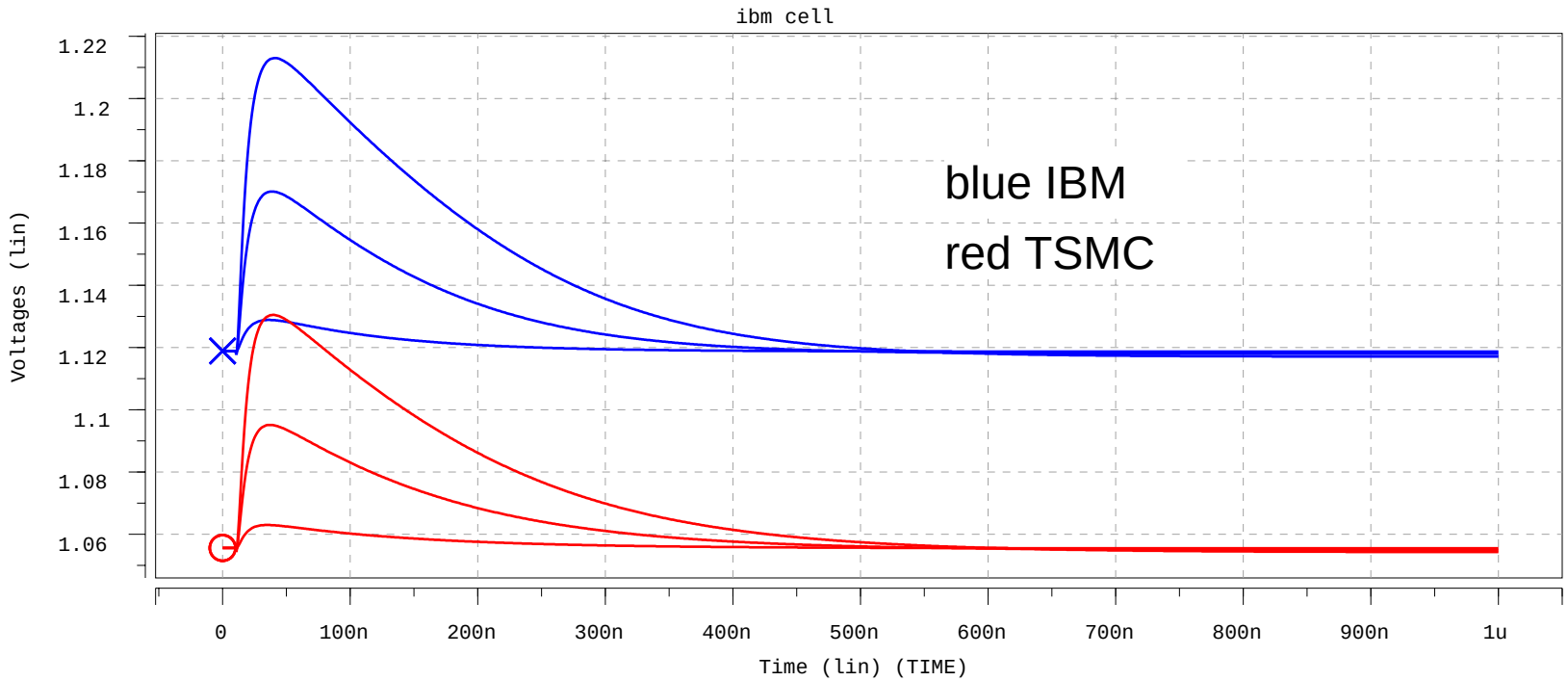

tsmc cell
Params (lin)
1.2
1
800m
600m
400m
200m
0
0
200n
400n
600n
800n
1u
Current X (lin) (AMPS)

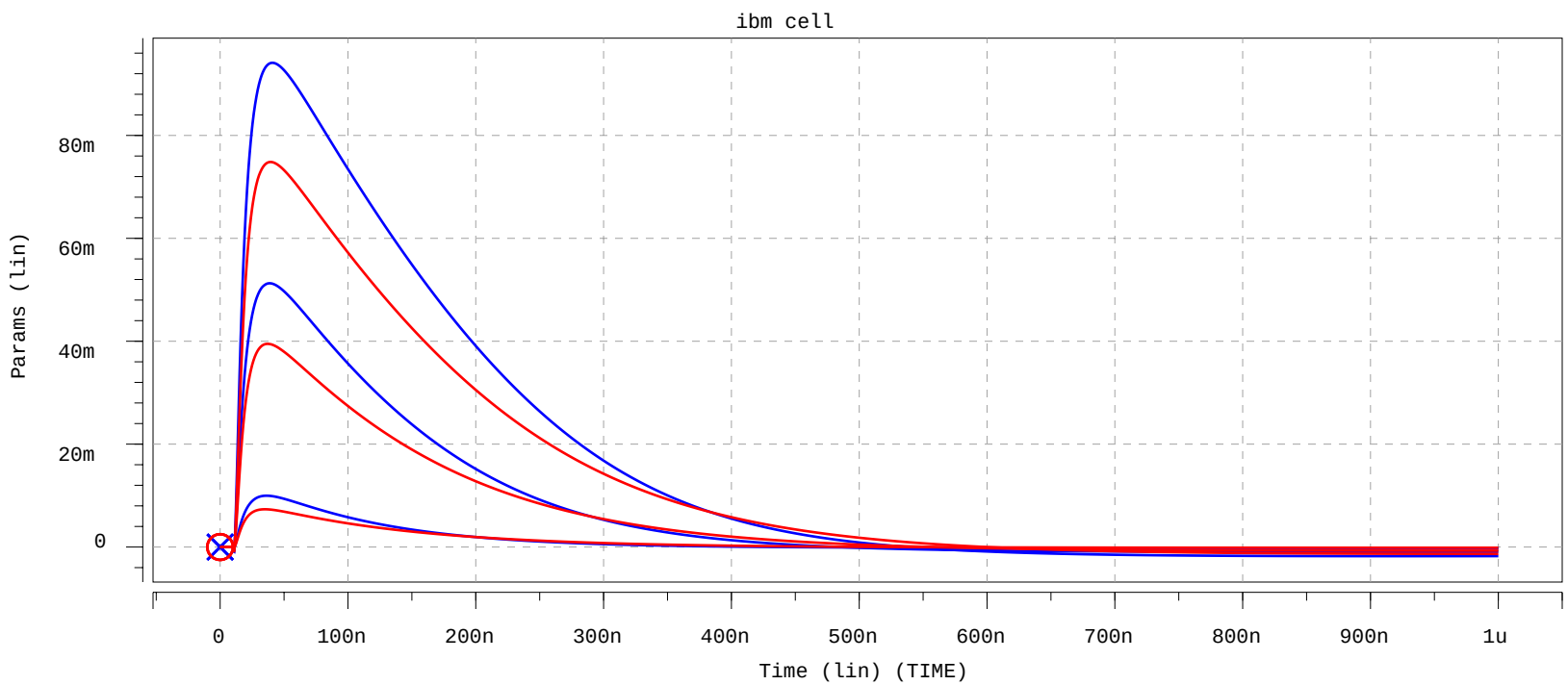

tsmc cell
Params (lin)
1.2
1
800m
600m
400m
200m
0
0
200n
400n
600n
800n
1u
Current X (lin) (AMPS)

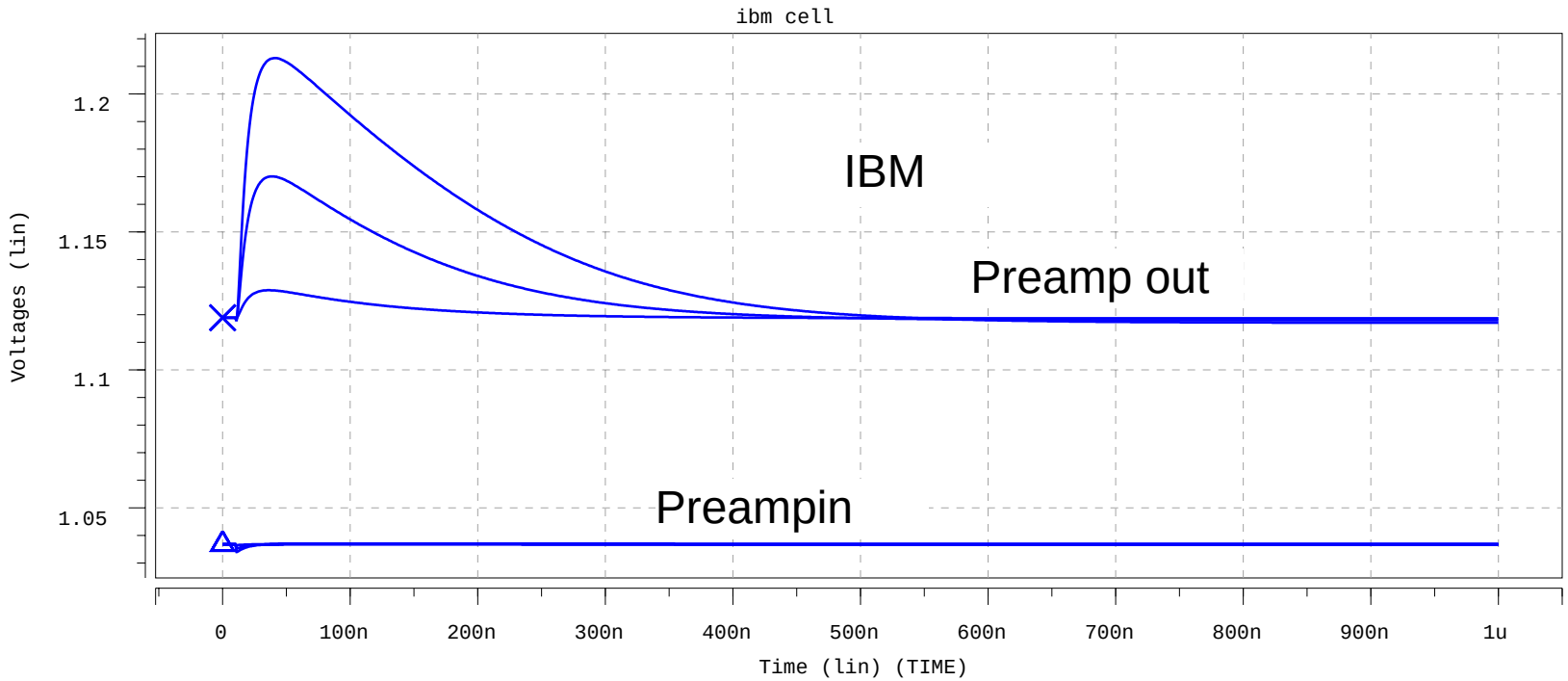

tsmc cell
Params (lin)
1.2
1
800m
600m
400m
200m
0
0
200n
400n
600n
800n
1u
Current X (lin) (AMPS)

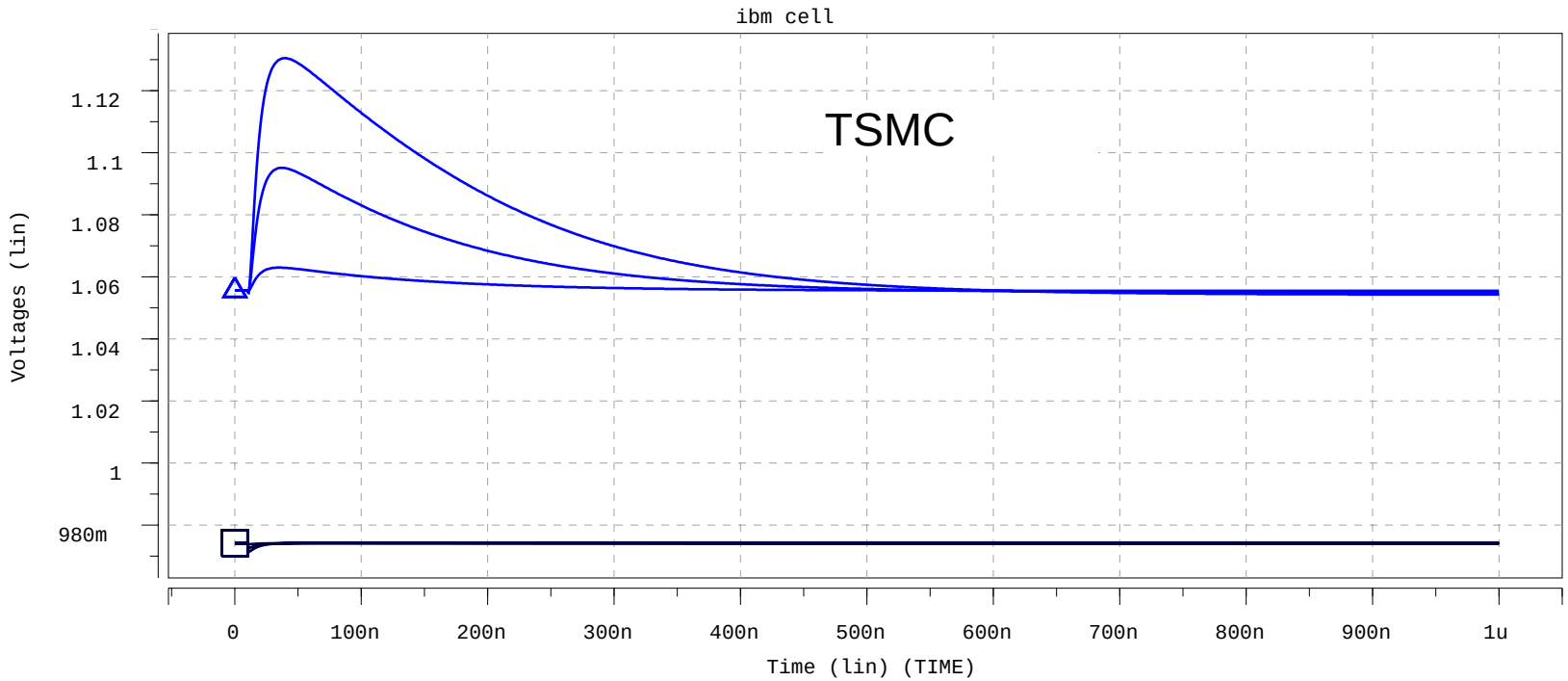

tsmc cell
Params (lin)
1.2
1
800m
600m
400m
200m
0
0
200n
400n
600n
800n
1u
Current X (lin) (AMPS)

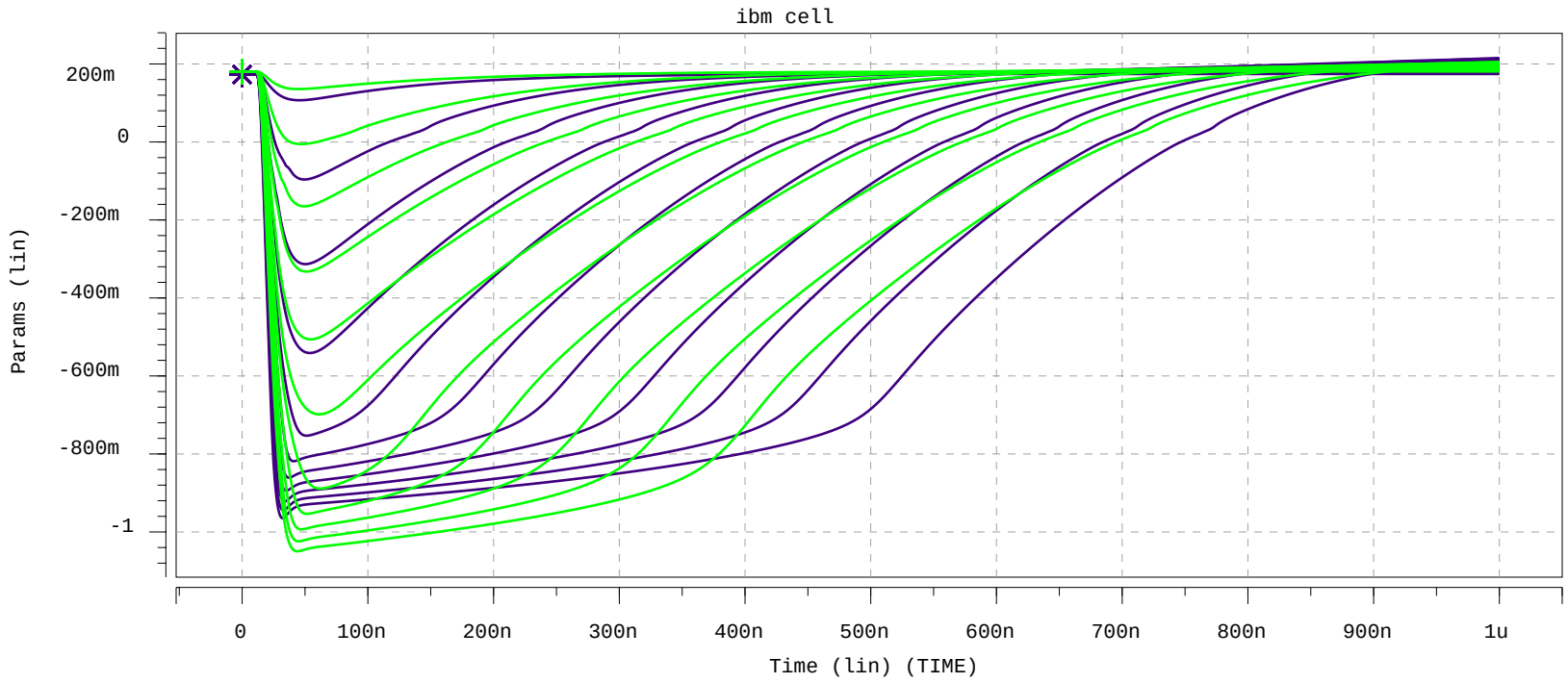
Comparison IBM/TSMC

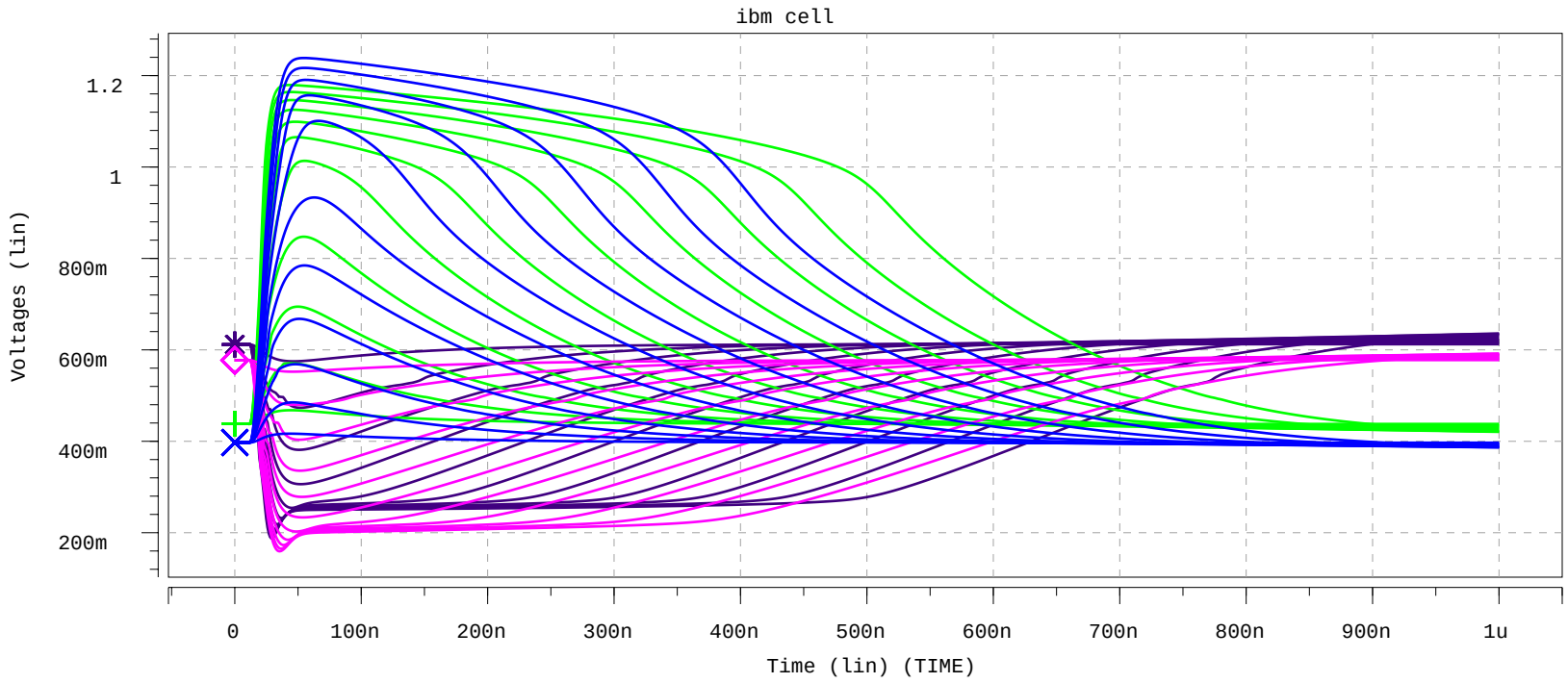

ibm cell
blue IBM
red TSMC
Voltages (lin)
1.22
1.2
1.18
1.16
1.14
1.12
1.1
1.08
1.06
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

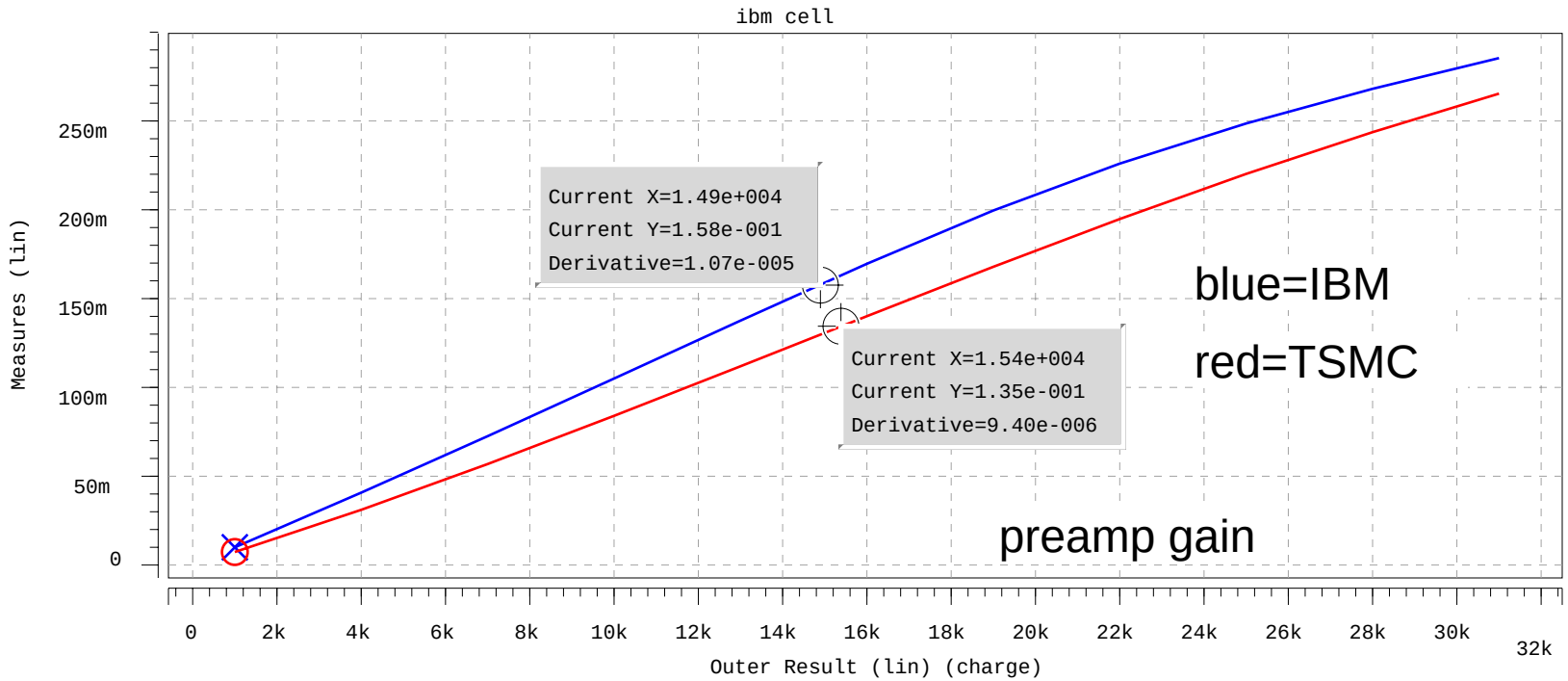

ibm cell
Params (lin)
80m
60m
40m
20m
0
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

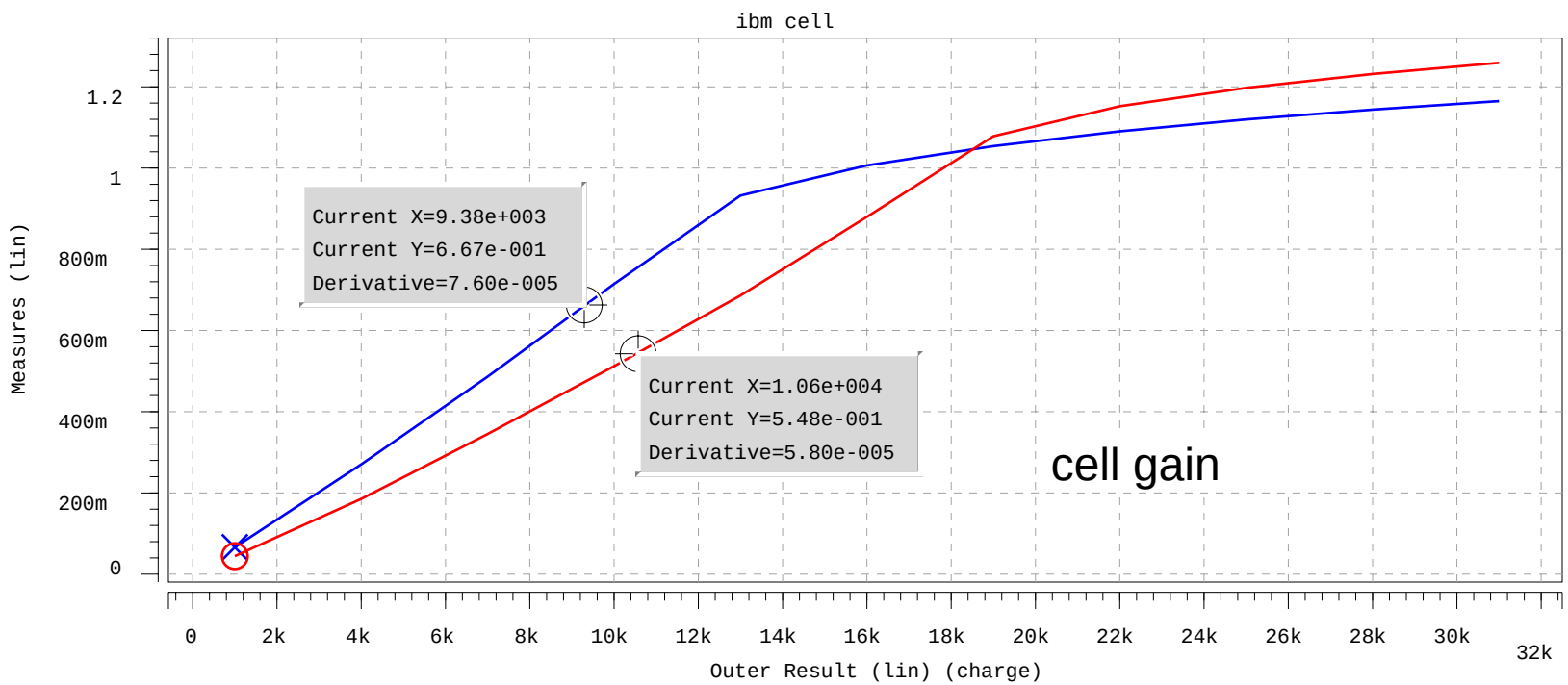

ibm cell
IBM
Preamp out
Preampin
Voltages (lin)
1.2
1.15
1.1
1.05
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

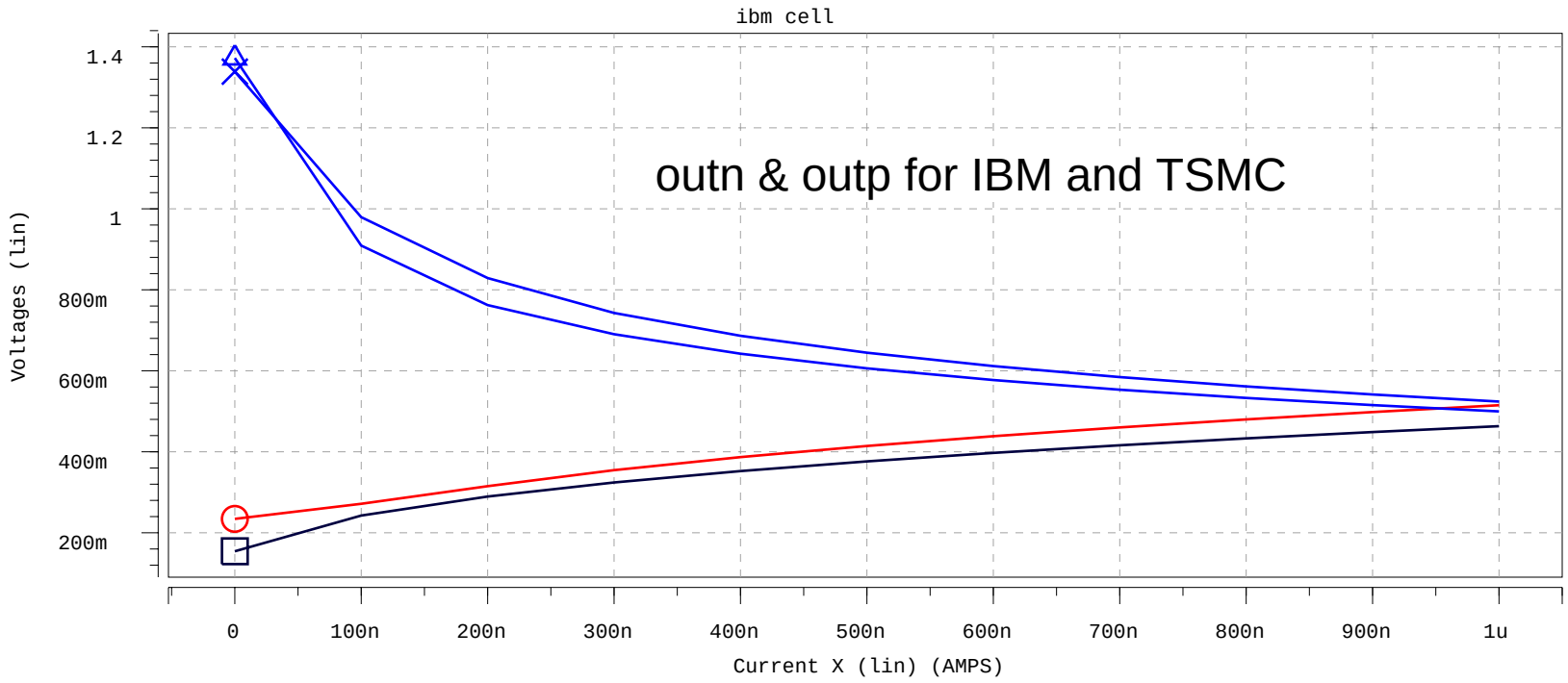

ibm cell
TSMC
Voltages (lin)
1.12
1.1
1.08
1.06
1.04
1.02
1
980m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)

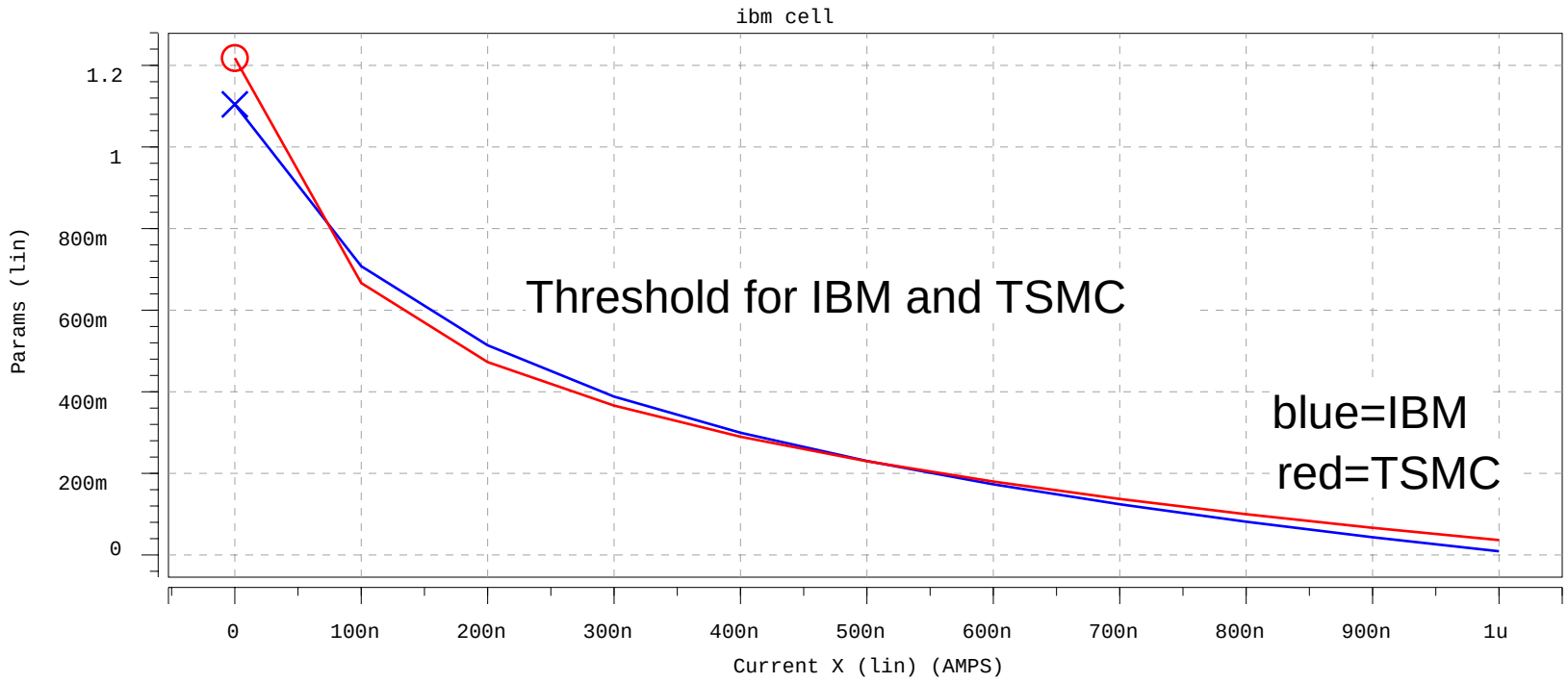

ibm cell
Params (lin)
200m
0
-200m
-400m
-600m
-800m
-1
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)


ibm cell
Voltages (lin)
1.2
1
800m
600m
400m
200m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Time (lin) (TIME)


ibm cell
Measures (lin)
250m
200m
150m
100m
50m
0
Current X=1.49e+004
Current Y=1.58e-001
Derivative=1.07e-005
Current X=1.54e+004
Current Y=1.35e-001
Derivative=9.40e-006
blue=IBM
red=TSMC
preamp gain
0
2k
4k
6k
8k
10k
12k
14k
16k
18k
20k
22k
24k
26k
28k
30k
32k
Outer Result (lin) (charge)

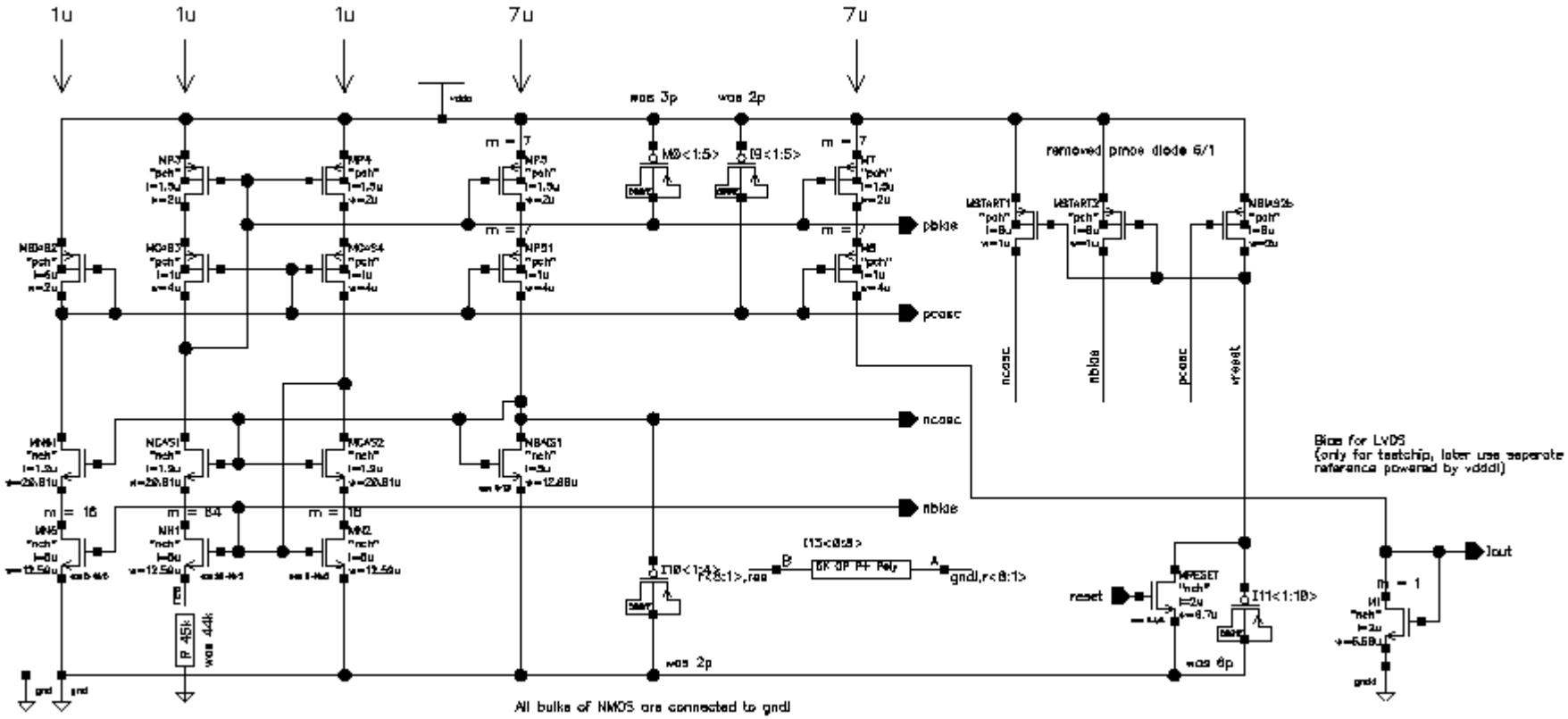

ibm cell
Measures (lin)
1.2
1
800m
600m
400m
200m
0
Current X=9.38e+003
Current Y=6.67e-001
Derivative=7.60e-005
Current X=1.06e+004
Current Y=5.48e-001
Derivative=5.80e-005
cell gain
0
2k
4k
6k
8k
10k
12k
14k
16k
18k
20k
22k
24k
26k
28k
30k
32k
Outer Result (lin) (charge)


ibm cell
outn & outp for IBM and TSMC
Voltages (lin)
1.4
1.2
1
800m
600m
400m
200m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Current X (lin) (AMPS)

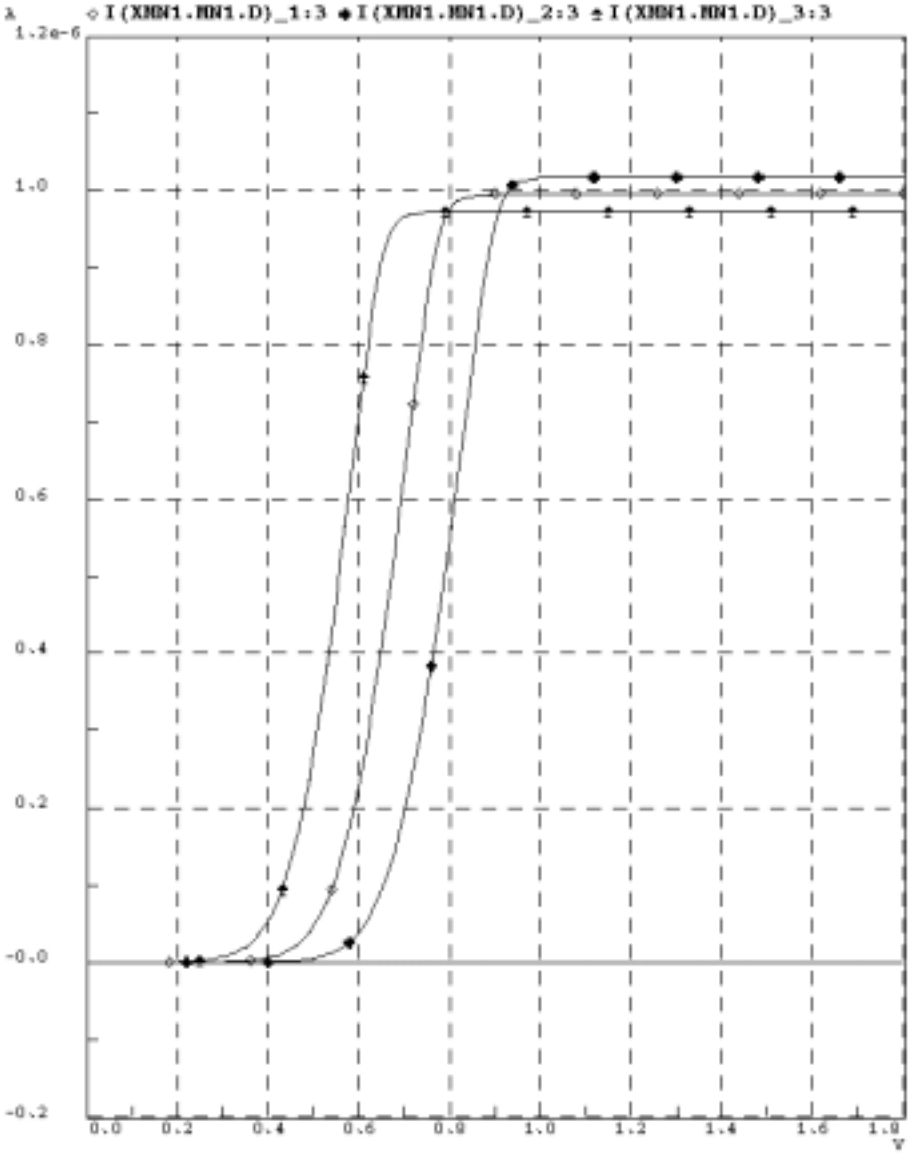

ibm cell
Threshold for IBM and TSMC
blue=IBM
red=TSMC
Params (lin)
1.2
1
800m
600m
400m
200m
0
100n
200n
300n
400n
500n
600n
700n
800n
900n
1u
Current X (lin) (AMPS)

Current reference, LVDS I/O

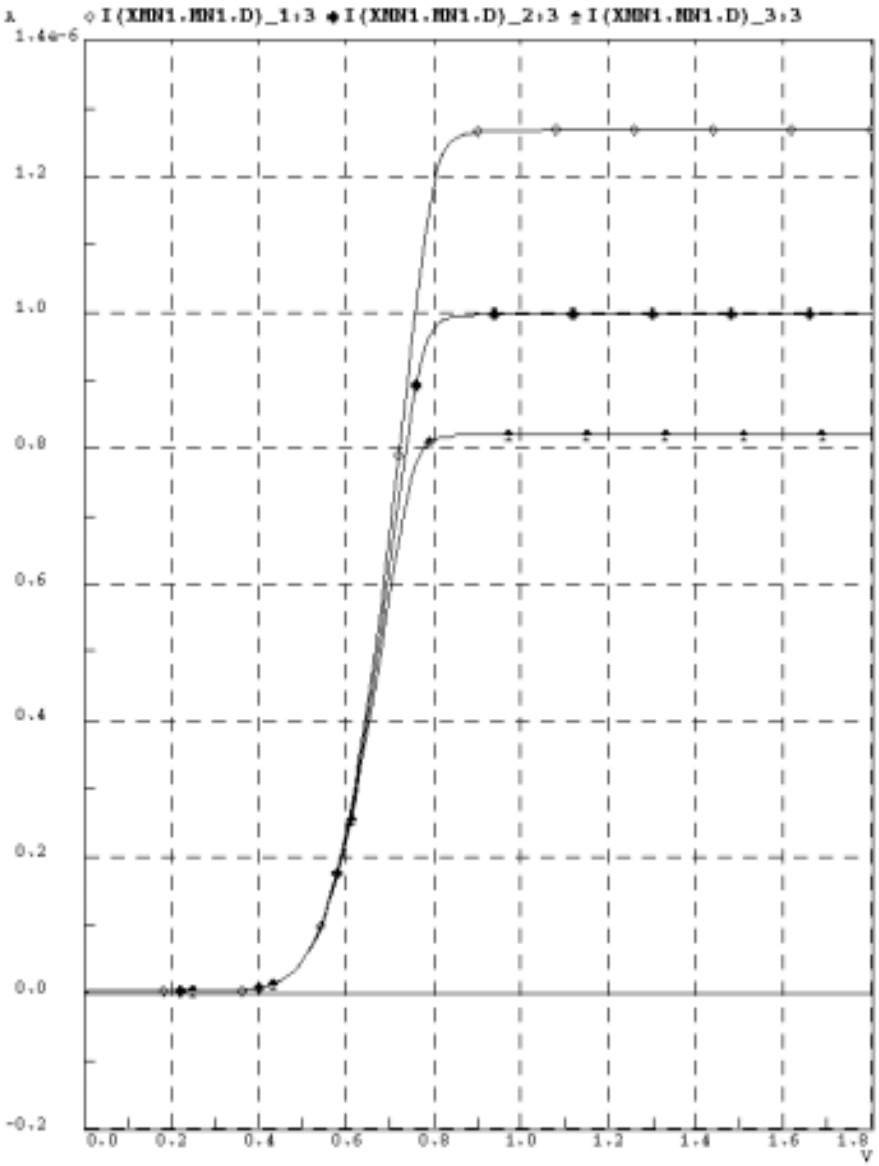
Current reference



- Start-up mechanism and external reset implemented
- Provide high output impedance and high dynamic range (wide-swing current mirror)

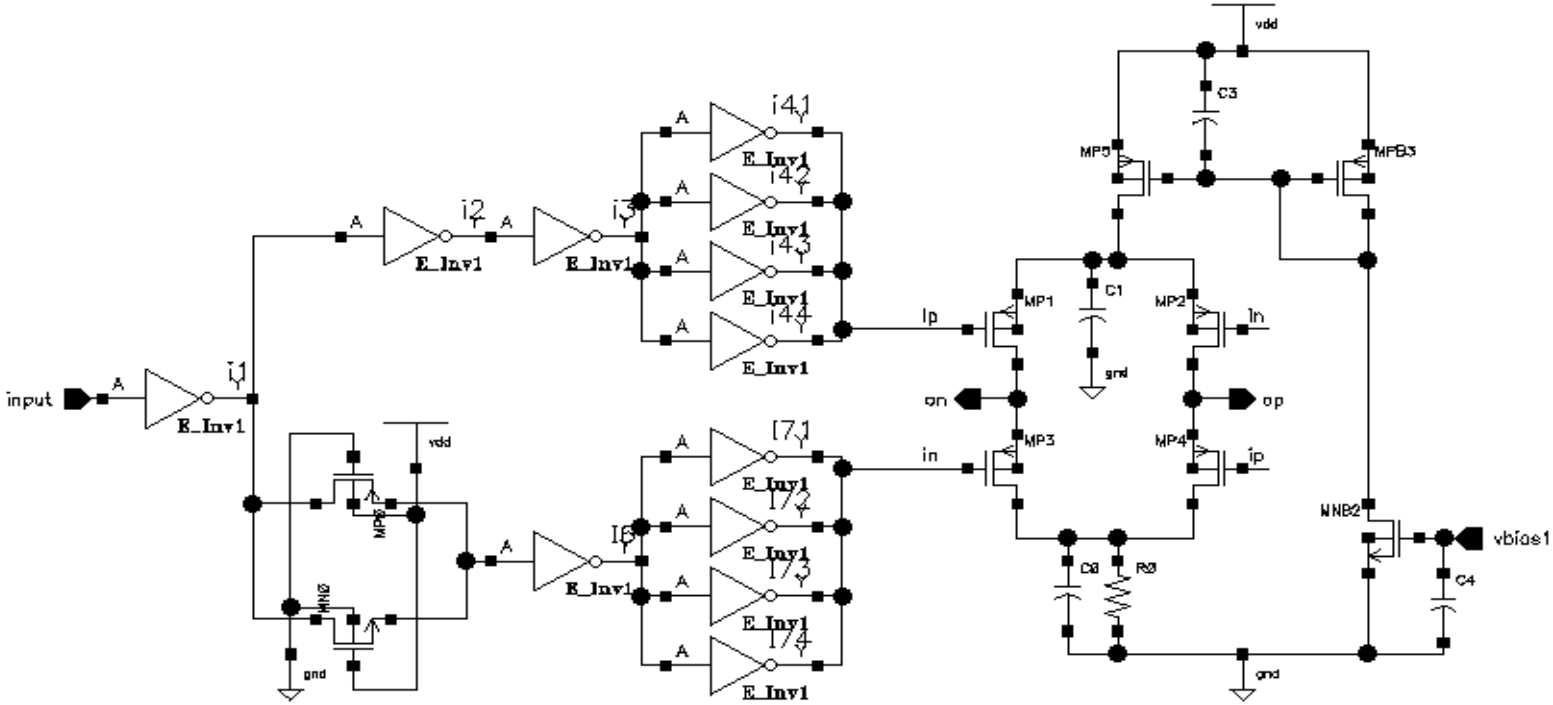


σ = -3, 0 and +3



ΔRref =+/- 20%

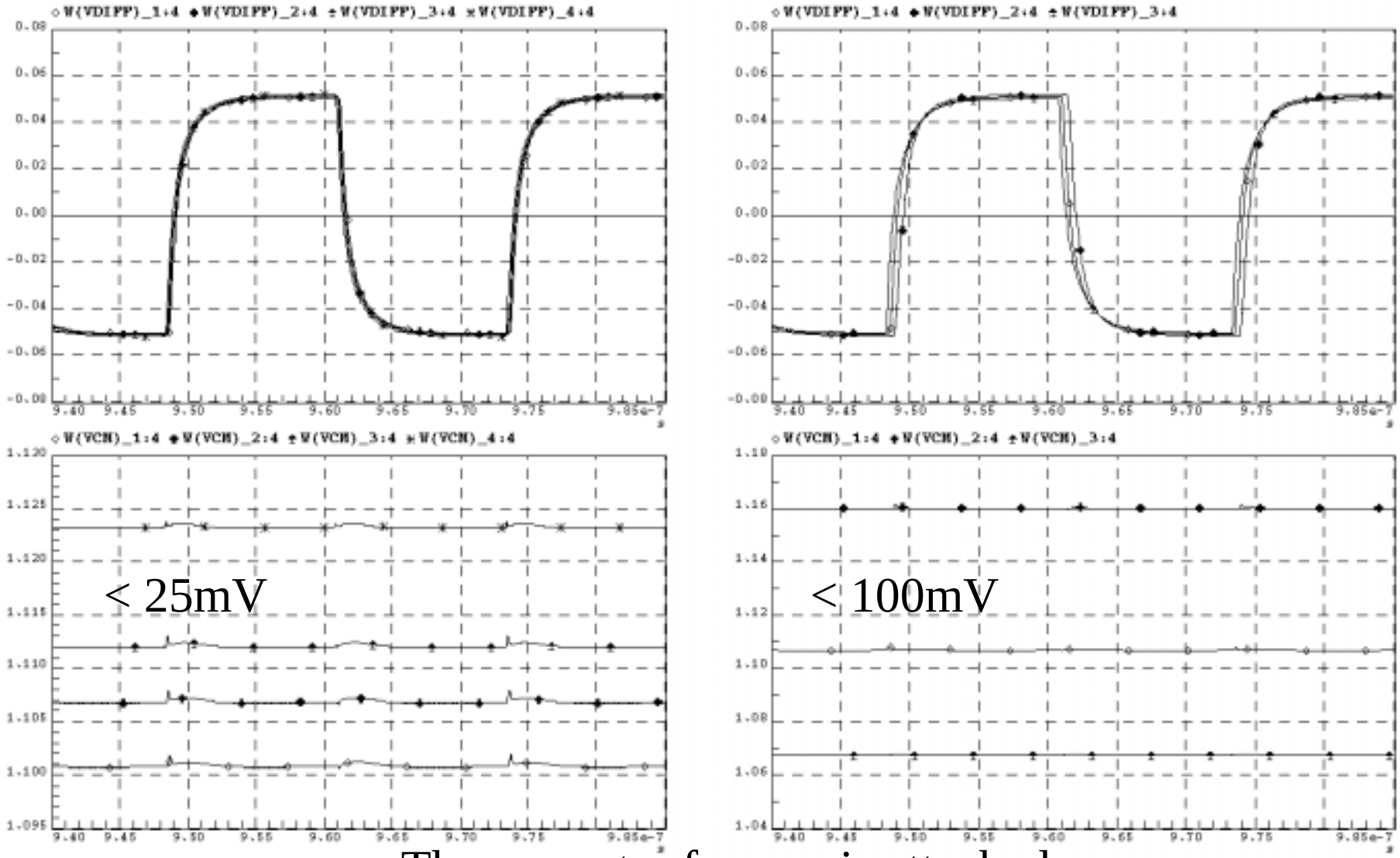
500µA LVDS driver



- Current controlled (LVDS I/O dedicated current reference)
- Common mode (set to 1.1V) independent of σ, power supply and reference resistor variation (same technique as for the chopper)
- 200Ω adapted

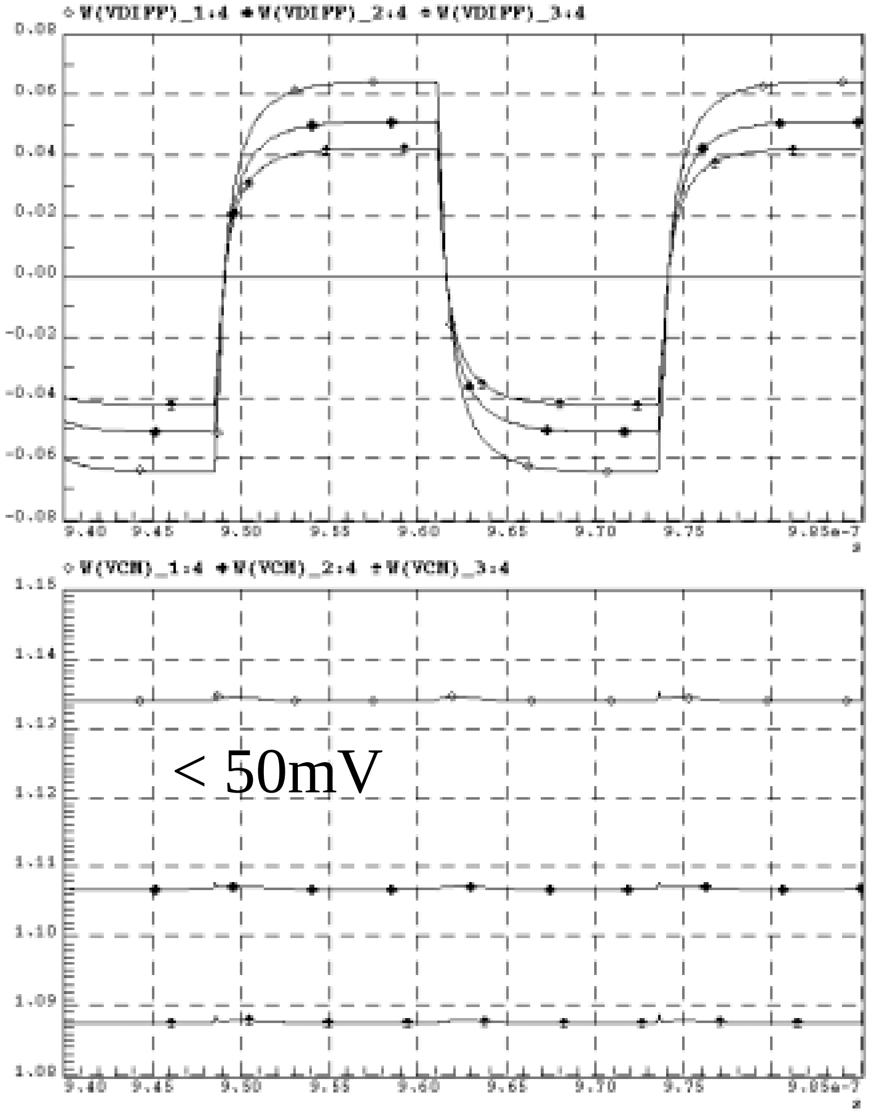
VDD=1.6, 1.8, 2 and 2.5V

σ = -3, 0 and +3

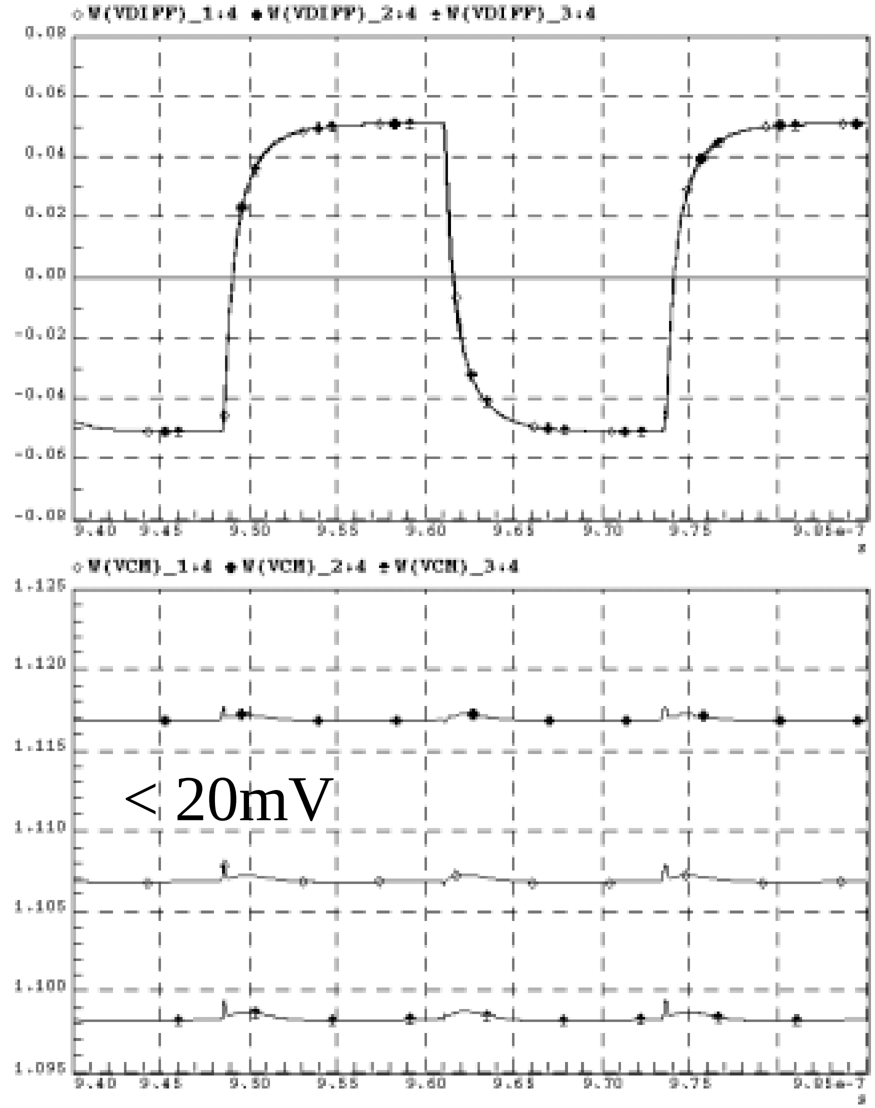


The current reference is attached

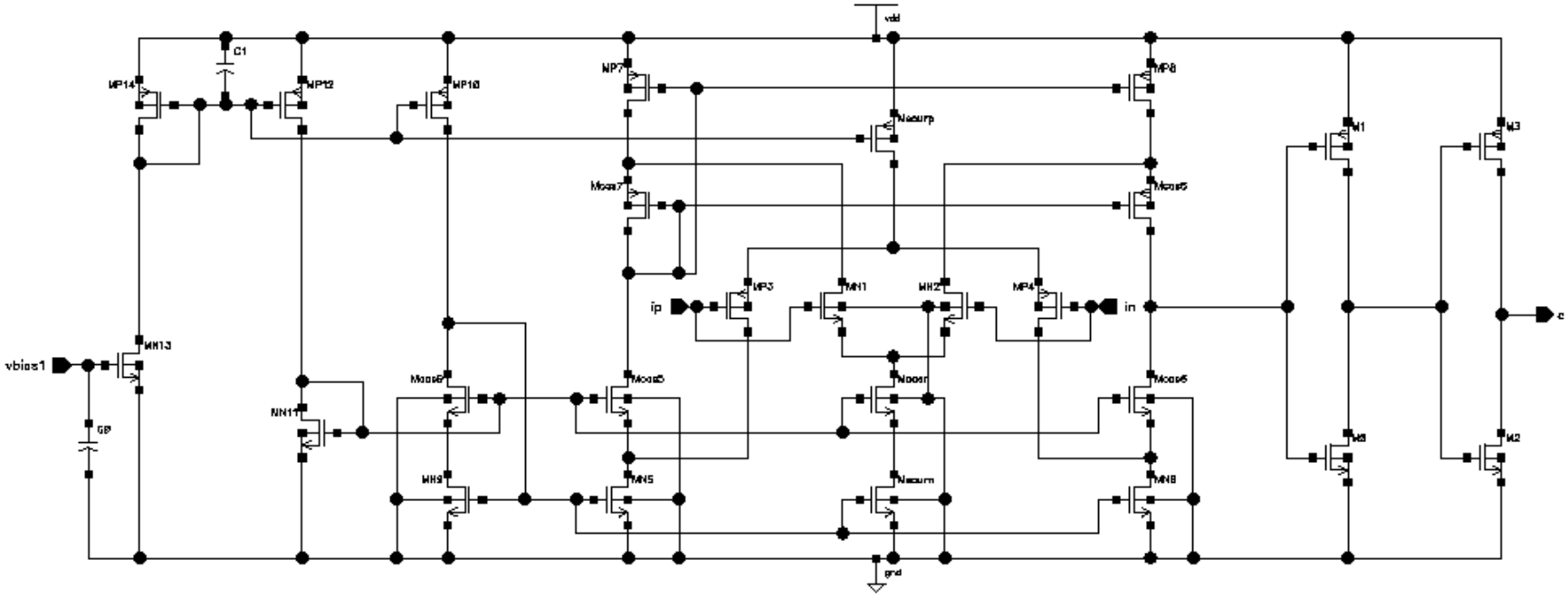
ΔRref =+/- 20%



npmis = -1, 0 and +1



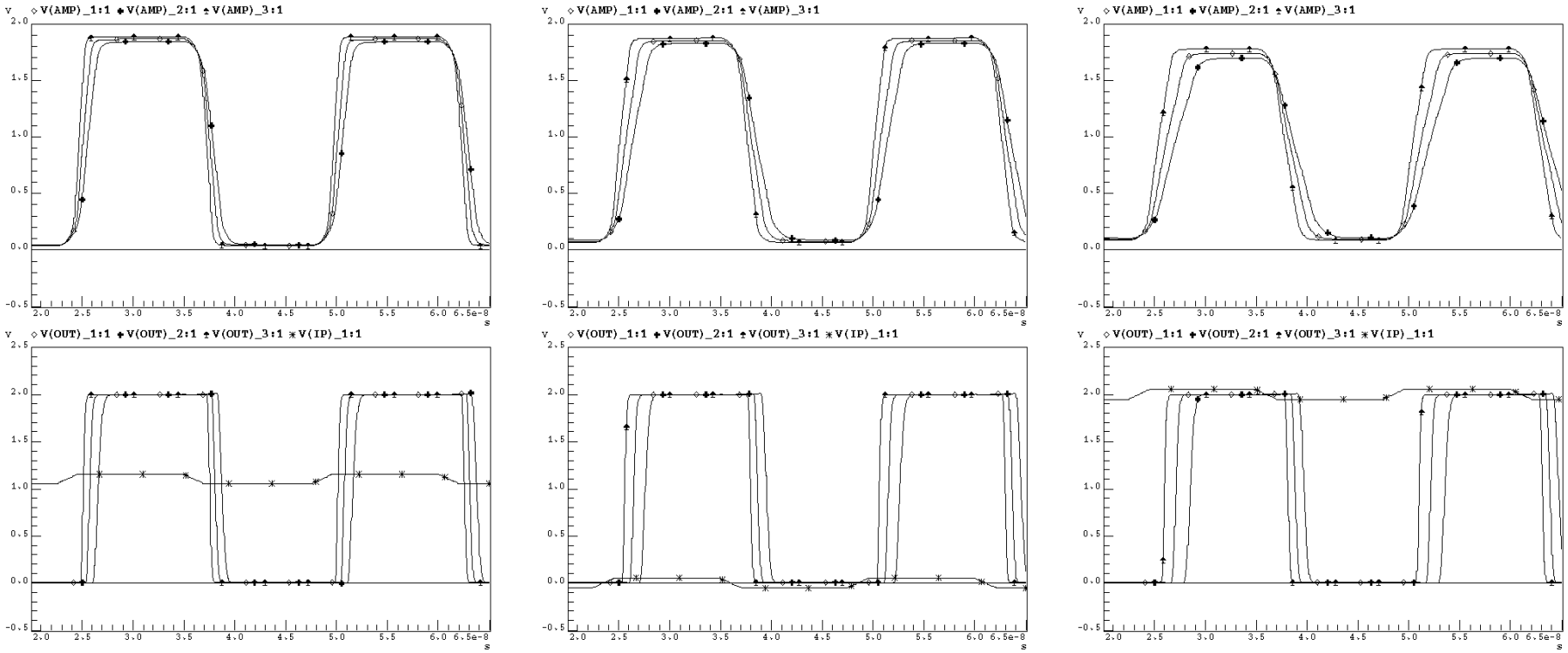
LVDS receiver



- Rail-to-rail feature
- Current controlled (140µA per differential pair)
  - The receiver in the design kit has a quiescent current varying from 2.5mA per branch to 1.4mA at VDD=2.5V (and 1.2mA<->0.5mA @VDD=2V)
- Successful operation down to 1.4V

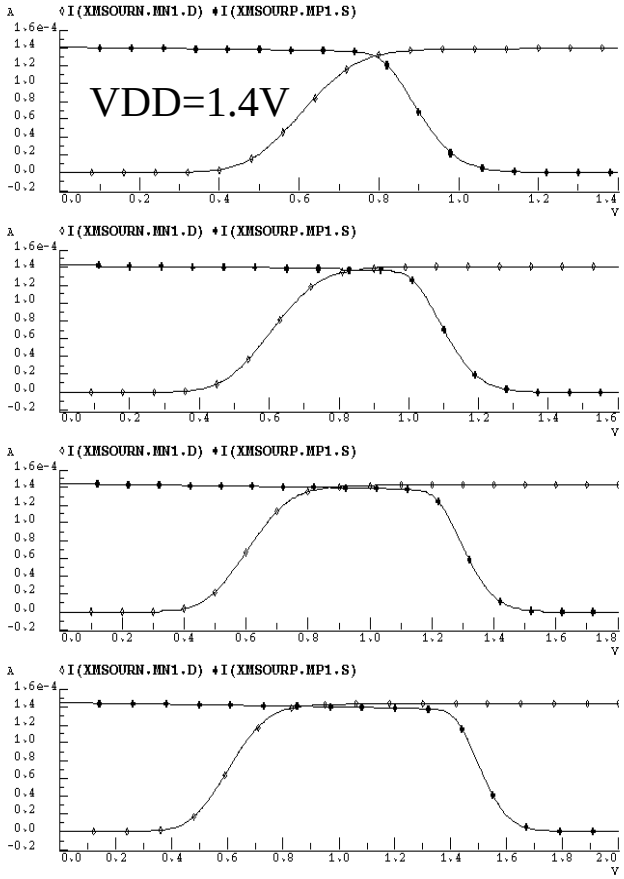
VDD=2V

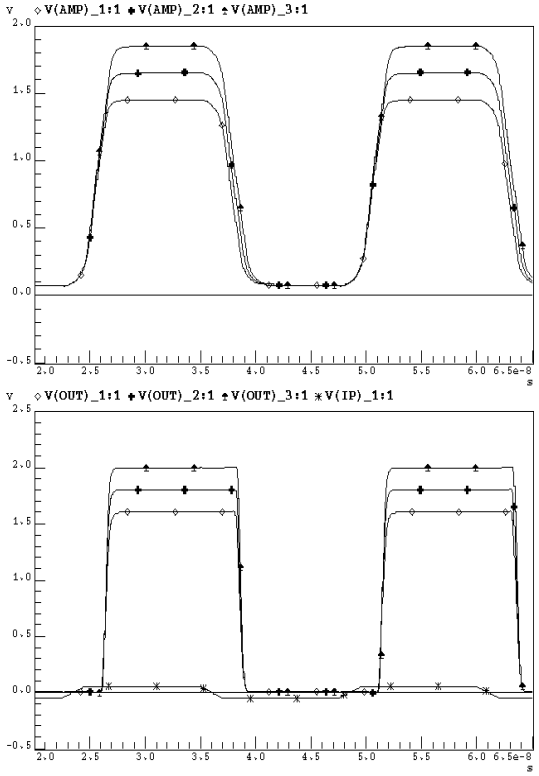
σ = -3, 0 and +3



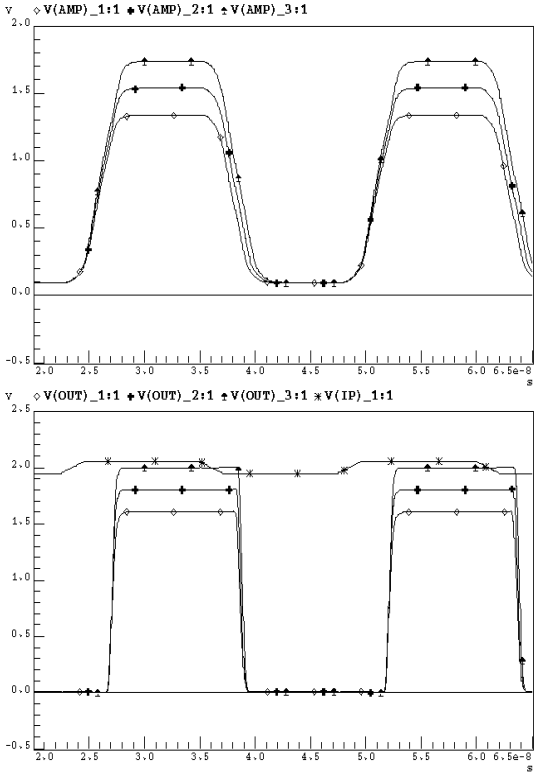
Vcm=1.1V Vcm=0V Vcm=2V

VDD=1.6, 1.8 and 2V





Vcm=0V



Vcm=Vdd