

Analog IC Design – Cadence Tools

Lab 12

Design Problem

The Design Challenge

- Part 1:
 - Two-stage SE output OTA
 - NMOS input stage
 - $V_{DD} = 1.8V$
 - $C_L = 1pF$
 - DC Gain > 60 dB
 - $UGF > 200MHz$
 - PM = 70-80 degree
 - Cgg of input stage < 100 fF
 - Minimize bias current

1-First we do a very rough hand analysis to get an initial point

$$Wu = \frac{gm1}{2\pi Cc} > 200MHz, \quad \text{assume } Cc = 0.5pf$$

$$gm1 > 628.3us$$

For $Cgg < 100f$,

$$\text{assume } \left(\frac{gm}{ID}\right)_1 = 14, \quad ID > 44.87uA, \quad IB1 > 89.75uA$$

$$\text{assume } PM = 76, \quad Wp2 = 4Wu, \quad \frac{gm2}{Cl} = \frac{4gm1}{Cc}$$

$$gm2 > 5026.4us$$

$$\text{assume } \left(\frac{gm}{ID}\right)_2 = 14, \quad IB2 > 359uA$$

$IB > 448uA$, so we need a large current here

2-Then We go to ADT to make an initial guess from Design Cockpit, then to the optimization interface to get an optimum point with my ranges that gives:

Optimization Settings
 DDB: A020005_1MEG_Miller.ddb | Properties | Initial Point: Best DDB Point | Corner: Nominal | Max No. of iterations: 20 | Constraints Strictness: Hard

DOFs

Name	Min	Max	Active
8 M5(GM/ID)	5	25	<input type="checkbox"/>
9 IB_Nominal	10u	4.996m	<input type="checkbox"/>
10 CC_Nominal	100f	1p	<input checked="" type="checkbox"/>
11 IB2/IB1	1	10	<input type="checkbox"/>

Constraints

Name	Min	Max	Weight	Active
1 DC Gain	1k	10k	1	<input type="checkbox"/>
2 DC PSR ...	-24.02	-411.1m	1	<input type="checkbox"/>
3 DC CMR ...	-24.09	16.23	1	<input type="checkbox"/>
4 Total Inpu...	575.4n	99.92u	1	<input type="checkbox"/>

Objectives

Name	Operation	Weight	Active
1 IB	Minimize	5	<input checked="" type="checkbox"/>

Optimization Results

DOF	Value	Output Variable	Nominal
1 M1(L)	427.5n	1 IB	1.906m
2 M2(L)	242.7n	2 UGF	198.6MEG
3 M3(L)	902.2n	3 PM	71.81
4 M4(L)	226.2n	4 DC Gain	1.098k
5 M5(L)	1.178u	5 DC PSR (dB)	-1.723

Buttons: Optimize, Send to, Verify

Schematic Diagram: A circuit schematic showing a differential pair (M1a, M1b) with a tail current source (M3), a load resistor (Rz), and a Miller capacitor (Cc). The output is taken from the differential pair (M2a, M2b) and the tail current source (M5). The input is Vin and the output is Vout.

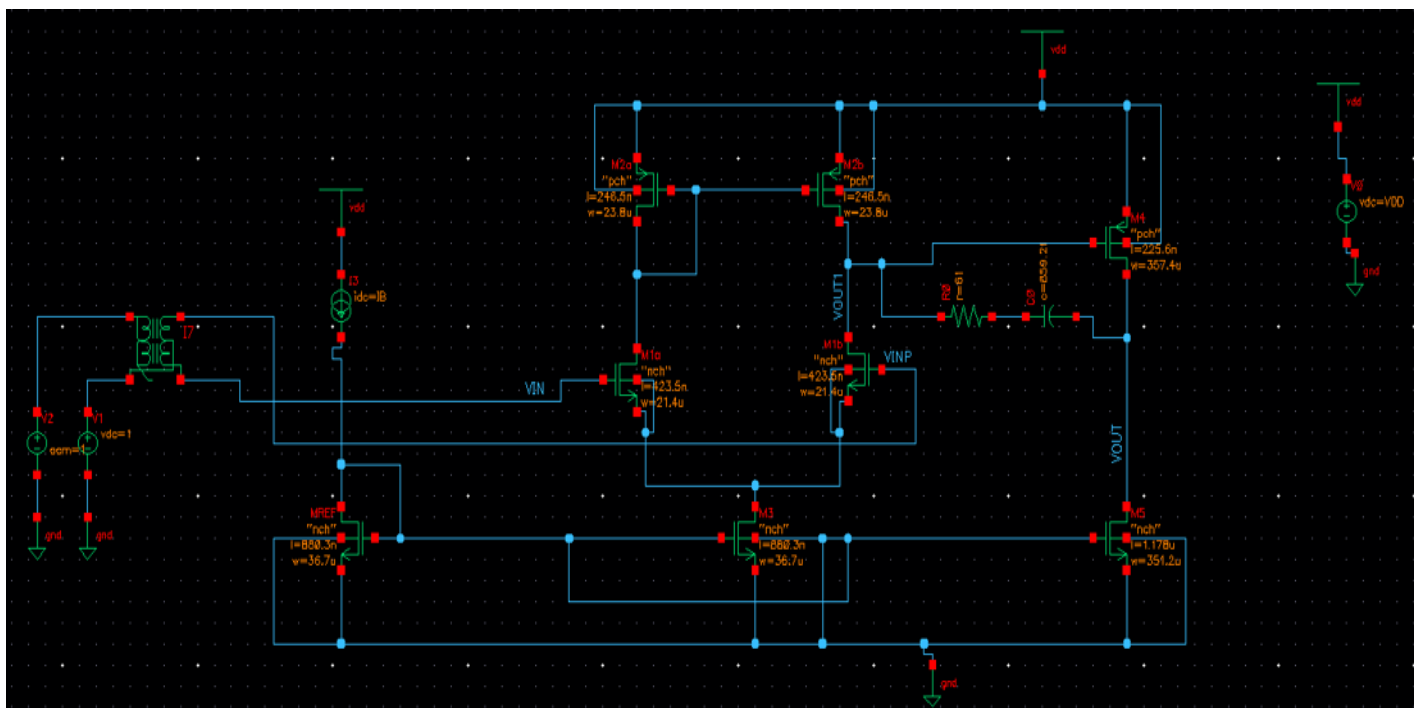
That point meets the specs with a large current but that's acceptable for now.

3-Then went to cadence to simulate this point and tune:

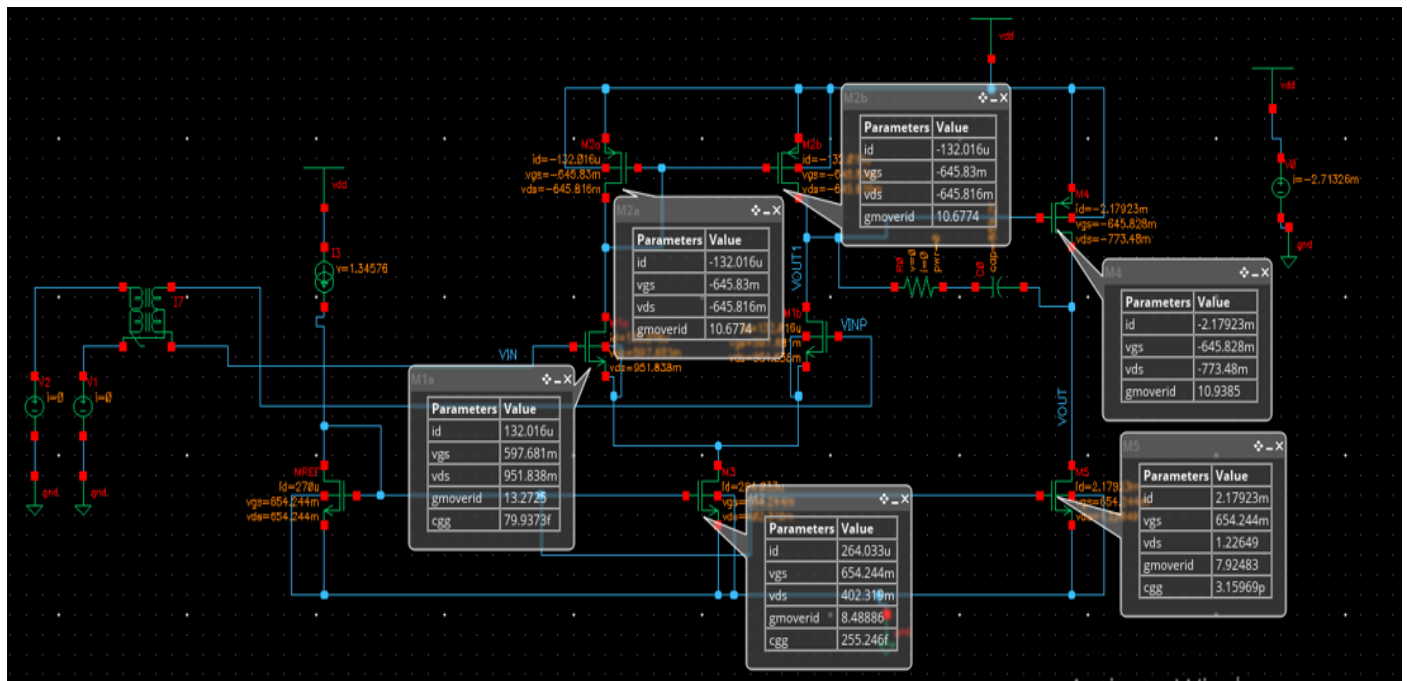
-That point gives UGF smaller than expected so we tuned to increase the current much again to meet the specs

-Finally, we reached that point:

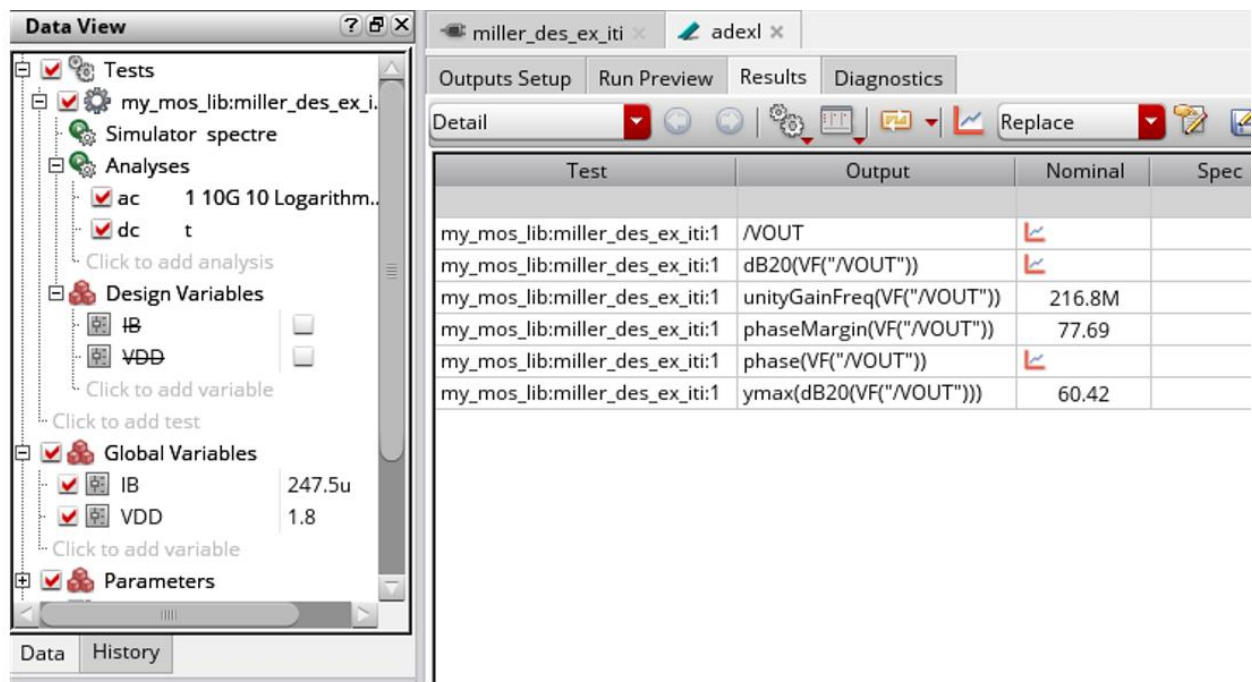
-Schematic with sizing:



-OP Point:



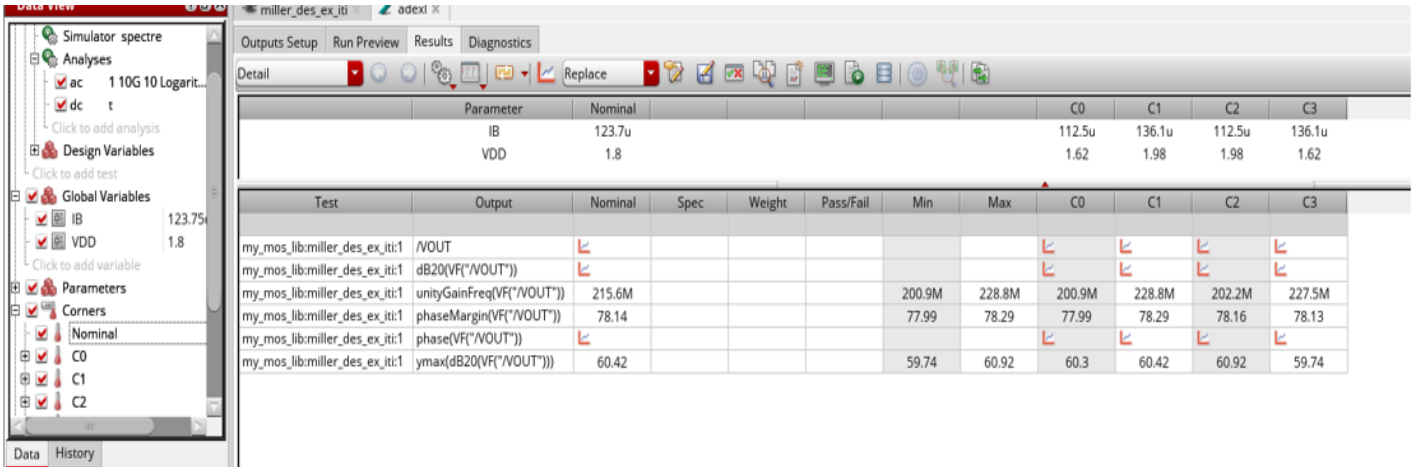
-Result:



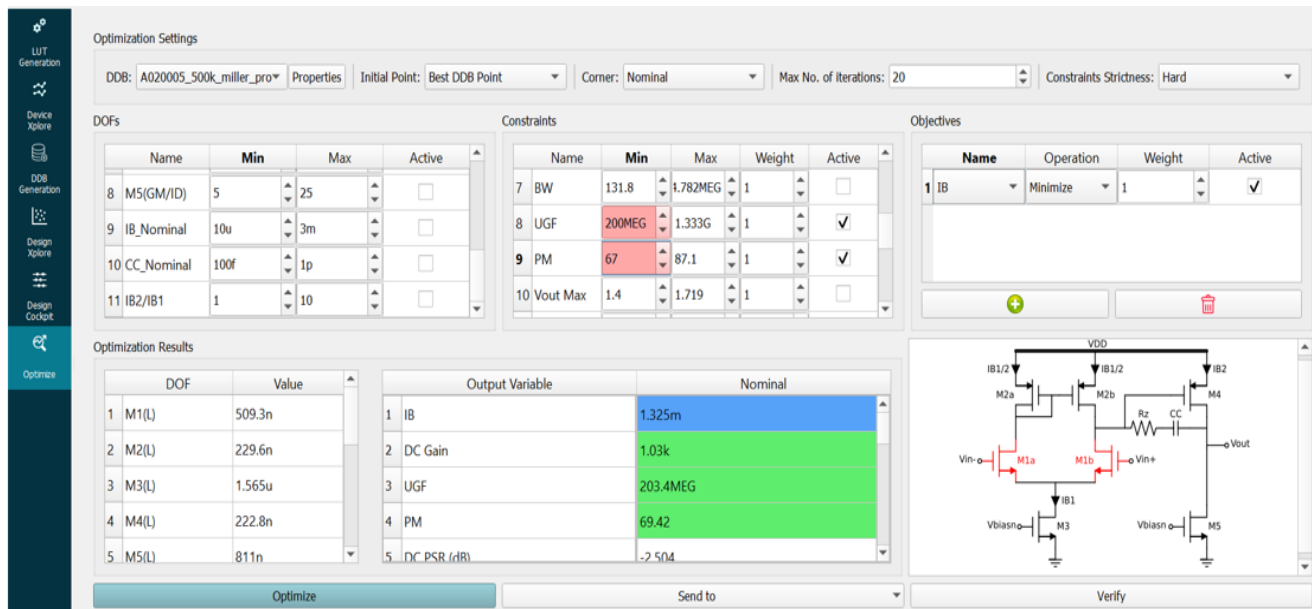
-We halved the reference current to be smaller than the needed current and halved its width to a practical view .

-Then we increase it with a small amount to meet the specs across corners that gives:

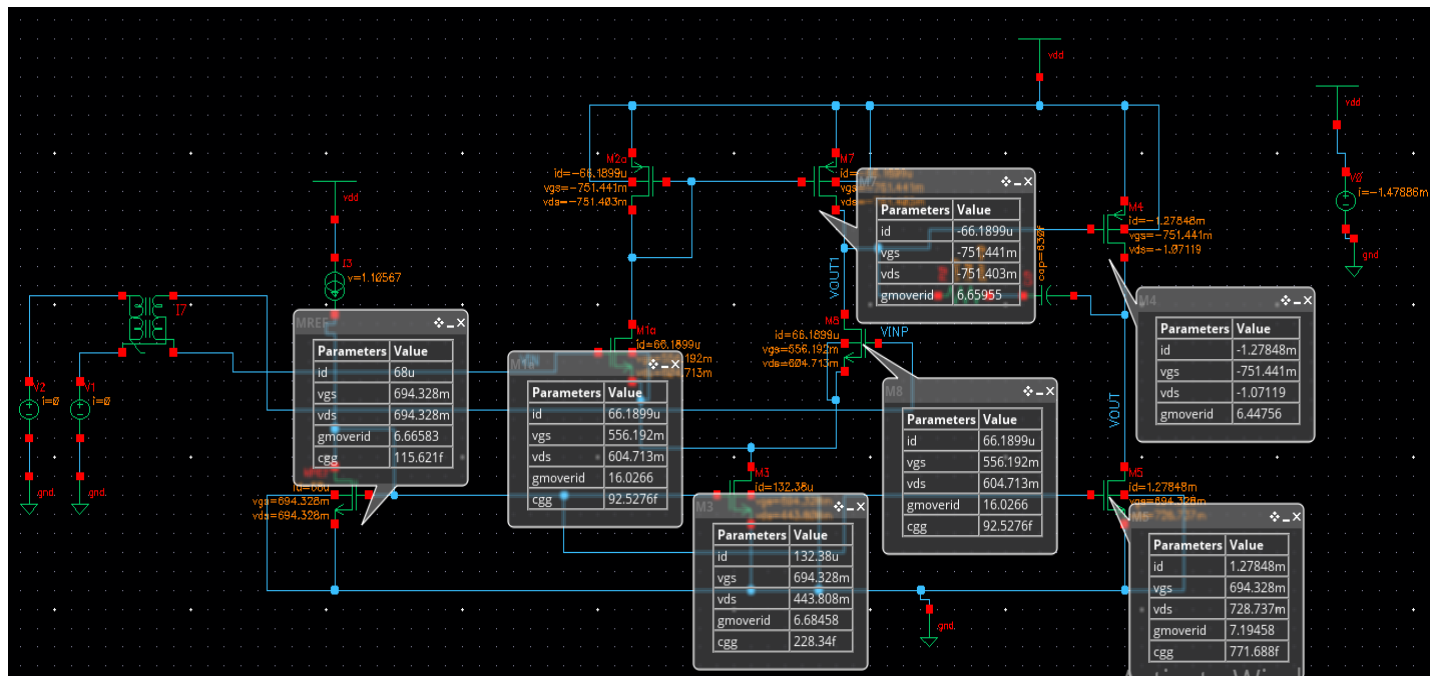
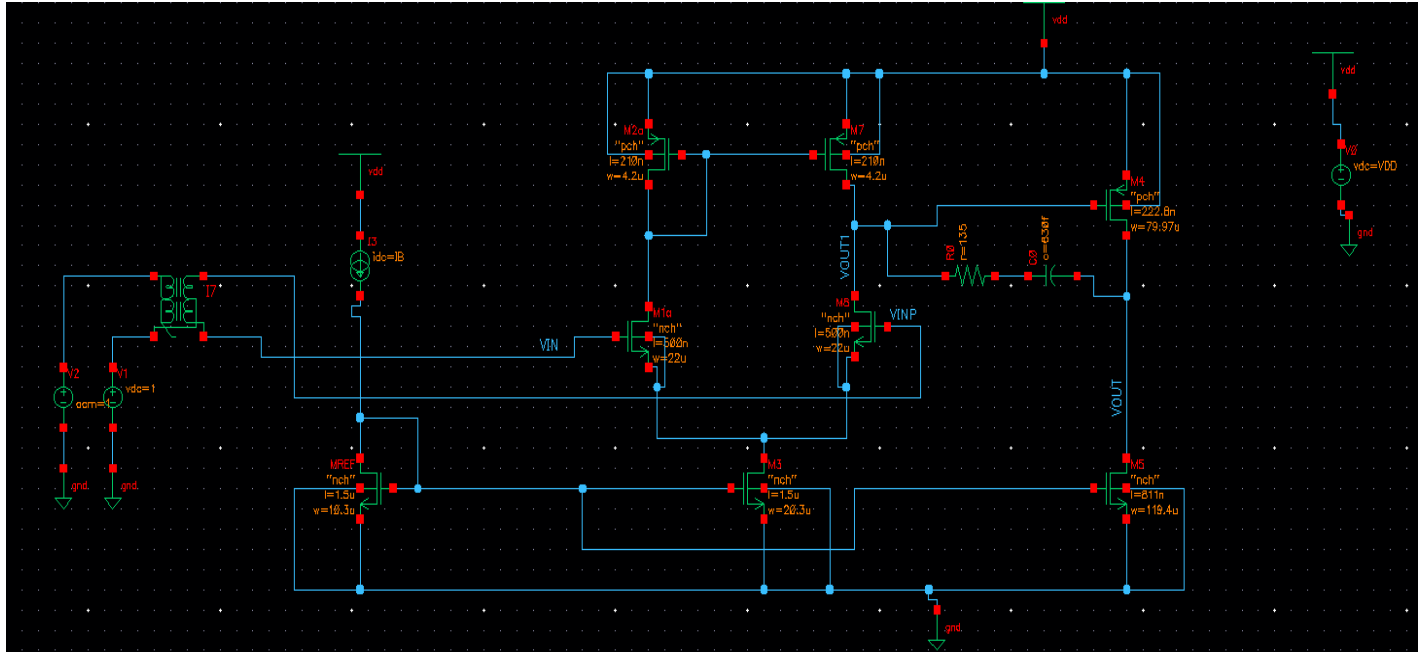
$$I_{B_tot} = 2.1\text{mA}$$



-That design meets all the specs but with large current, so we go to ADT again to tune after the hint that Dr Hesham gives us, increasing VINCM (corner) to 1.2, that gives a better point that meets the specs with a smaller current:



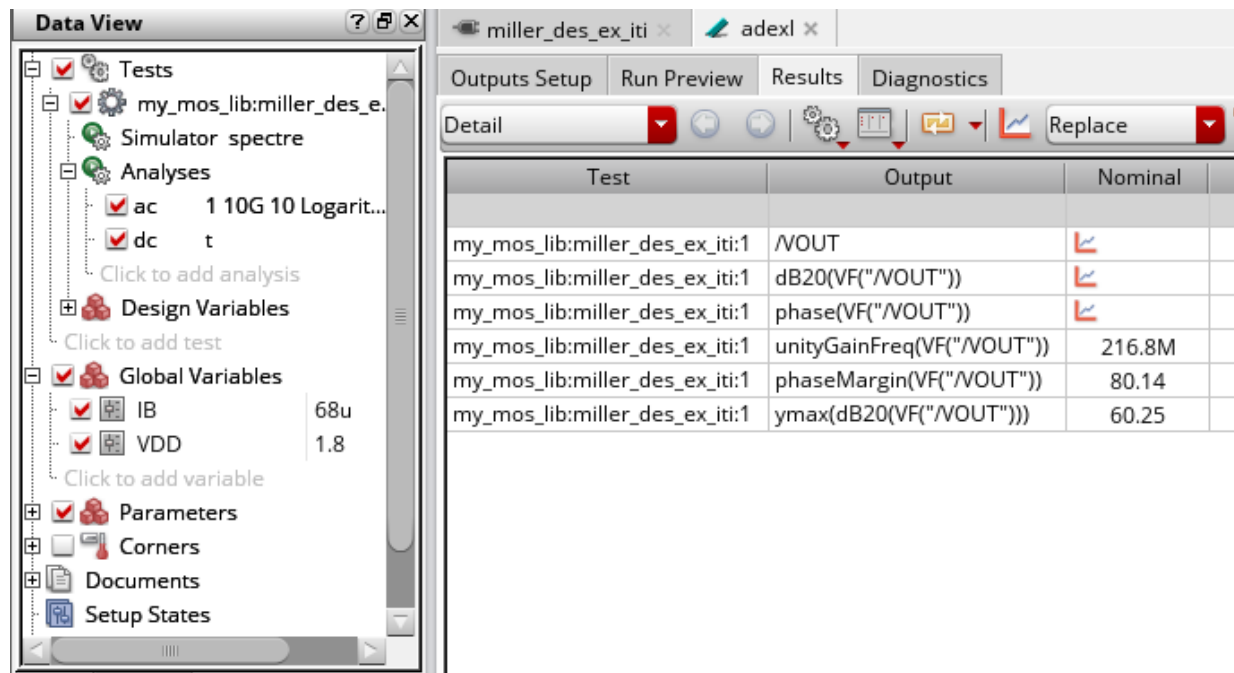
- Simulate that point:



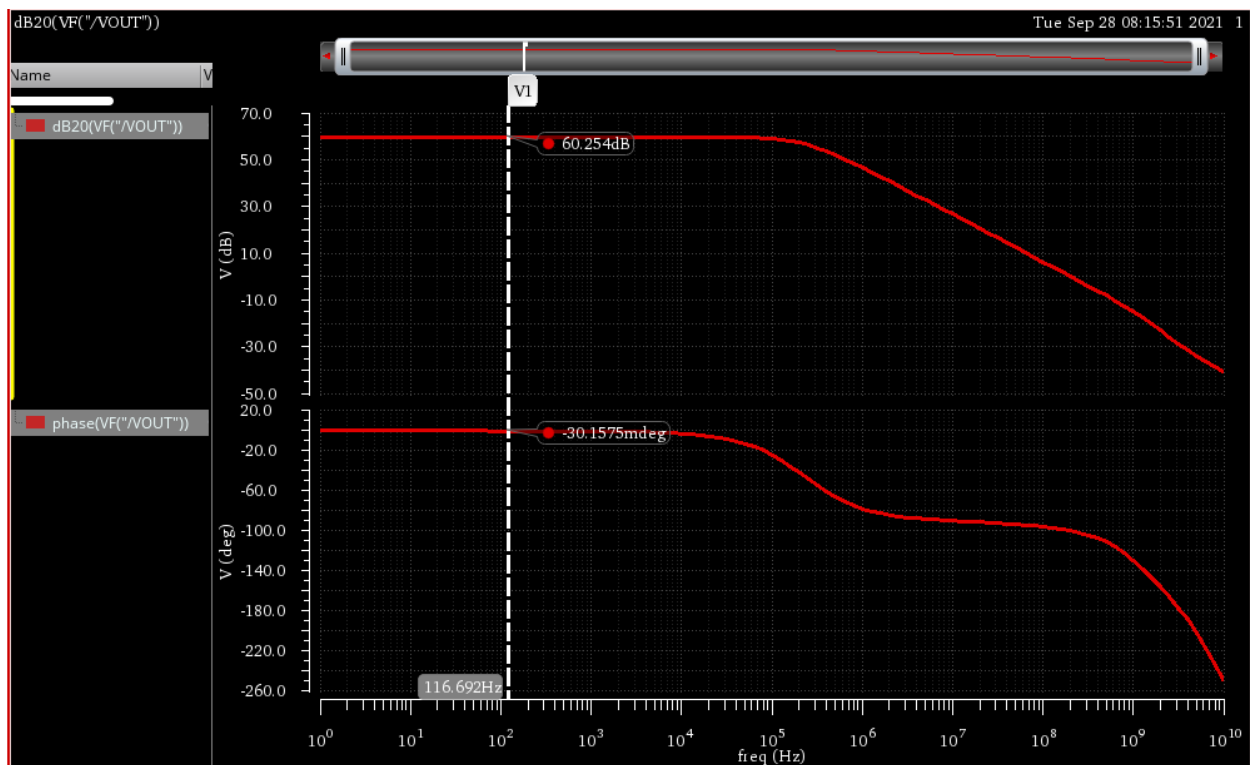
-That point doesn't achieve the gain spec, so we increased L2 a little more to give us the needed gain.

$$Av = gm1(ro1 || ro2) * Av2$$

$$Av = gm1(ro1||ro2) * Av2$$



-That point meets the specs with $IB_{tot} = 1.4m$



-Results across corners:

Outputs Setup Run Preview Results Diagnostics											
Detail											
Replace											
Parameter		Nominal						C0	C1	C2	C3
IB		68u						62u	74.4u	62u	74.4u
VDD		1.8						1.62	1.98	1.98	1.62

Test	Output	Nominal	Spec	Weight	Pass/Fail	Min	Max	C0	C1	C2	C3
my_mos_lib:miller_des_ex_it1:1	/VOUT										
my_mos_lib:miller_des_ex_it1:1	dB20(VF("/VOUT"))										
my_mos_lib:miller_des_ex_it1:1	phase(VF("/VOUT"))										
my_mos_lib:miller_des_ex_it1:1	unityGainFreq(VF("/VOUT"))	216.8M				200.6M	230.9M	200.6M	230.9M	202.5M	228.6M
my_mos_lib:miller_des_ex_it1:1	phaseMargin(VF("/VOUT"))	80.14				80.03	80.26	80.03	80.26	80.25	80.05
my_mos_lib:miller_des_ex_it1:1	ymax(dB20(VF("/VOUT")))	60.25				59.21	60.69	59.62	60.65	60.69	59.21

-We achieved all the specs with IB_min = 1.28mA

-All of you, Thanks for everything.