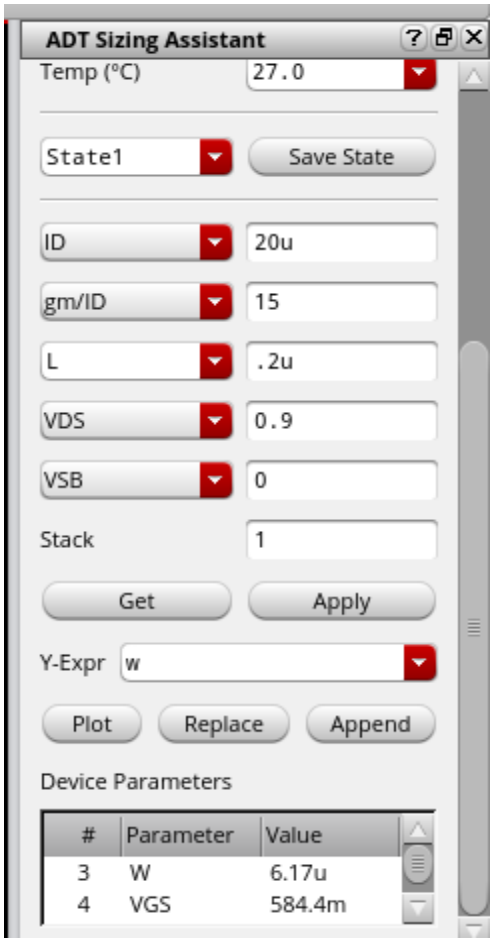
PART 2: OTA Design

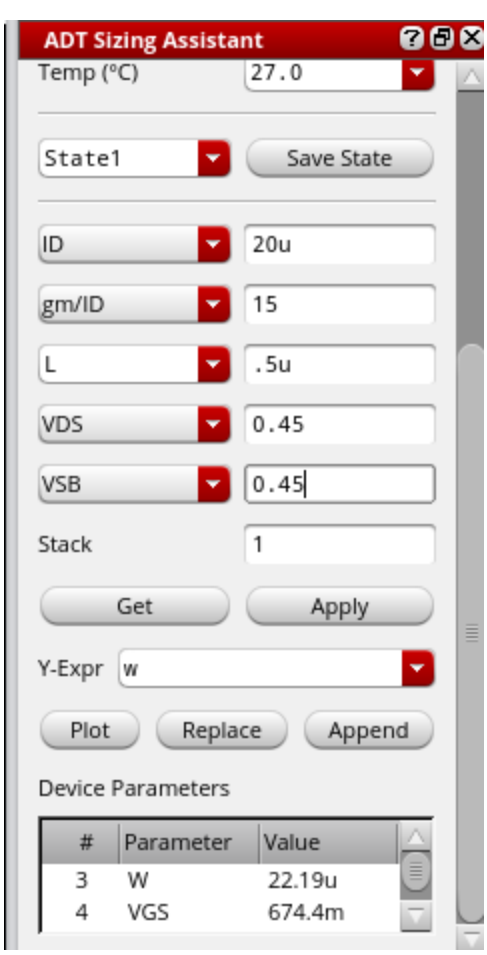
For the input pair use short L and bias it in MI or WI, e.g., L = 0.2um and gm/ID = 15. This maximizes the GBW (good efficiency) and minimizes the input capacitive loading (avoid reducing the DC LG). You will have to tune your gm/ID to achieve the CL bandwidth spec.

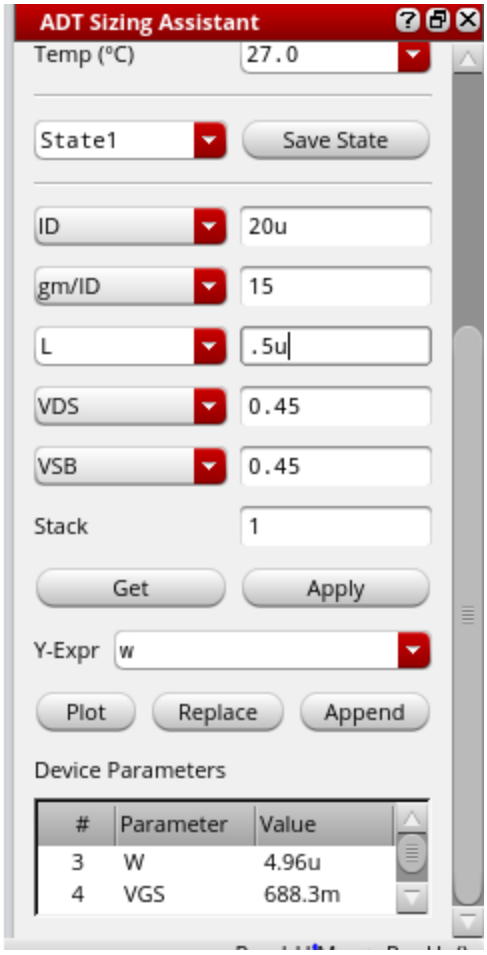


For the current source transistors use relatively long L and bias them in SI, e.g., L = 1um and gm/ID = 10. These transistors contribute significant offset and noise. A large gm will not help the gain but will increase the noise

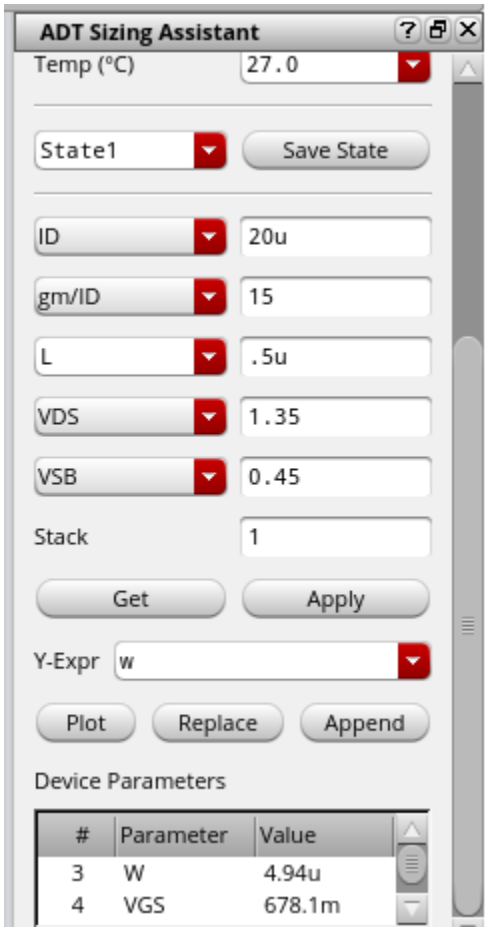

ADT Sizing Assistant
Temp (°C)
27.0
State1
Save State
ID
40u
gm/ID
10
L
1u
VDS
0.45
VSB
0
Stack
1
Get
Apply
Y-Expr
w
Plot
Replace
Append
Device Parameters
Parameter Value
3 W 8.59u
4 VGS 616m
ADT Sizing Assistant
Temp (°C)
27.0
State1
Save State
ID
20u
gm/ID
10
L
1u
VDS
0.45
VSB
0
Stack
1
Get
Apply
Y-Expr
w
Plot
Replace
Append
Device Parameters
Parameter Value
3 W 17.47u
4 VGS 610.4m

For the cascode transistors use moderate L and bias them in MI or WI, e.g., L = 0.5um and gm/ID = 15. These transistors do not contribute significant offset and noise, so they don't need to be large. A large gm helps the gain and doesn't increase the noise.





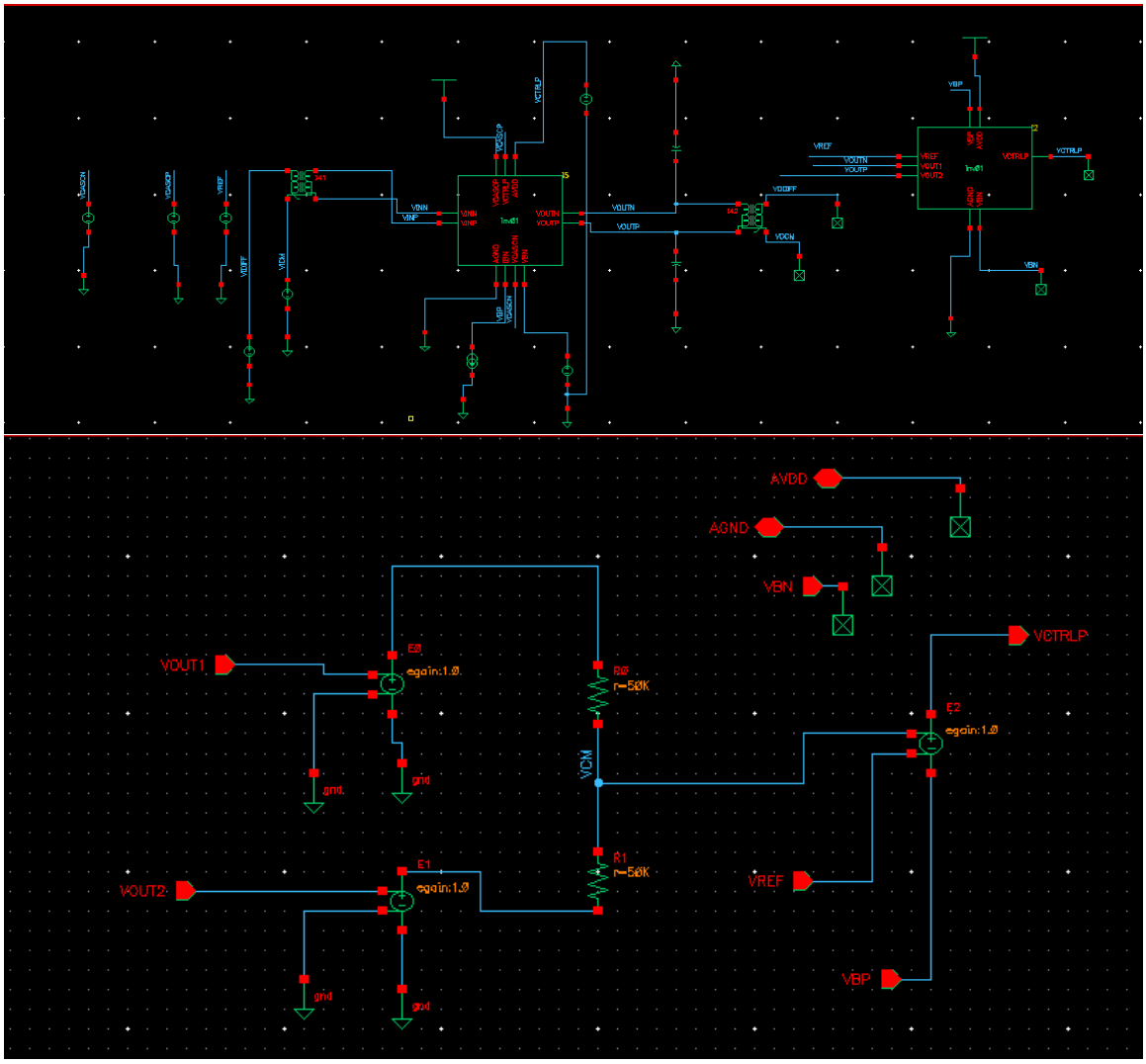
-For the transistor under VBN



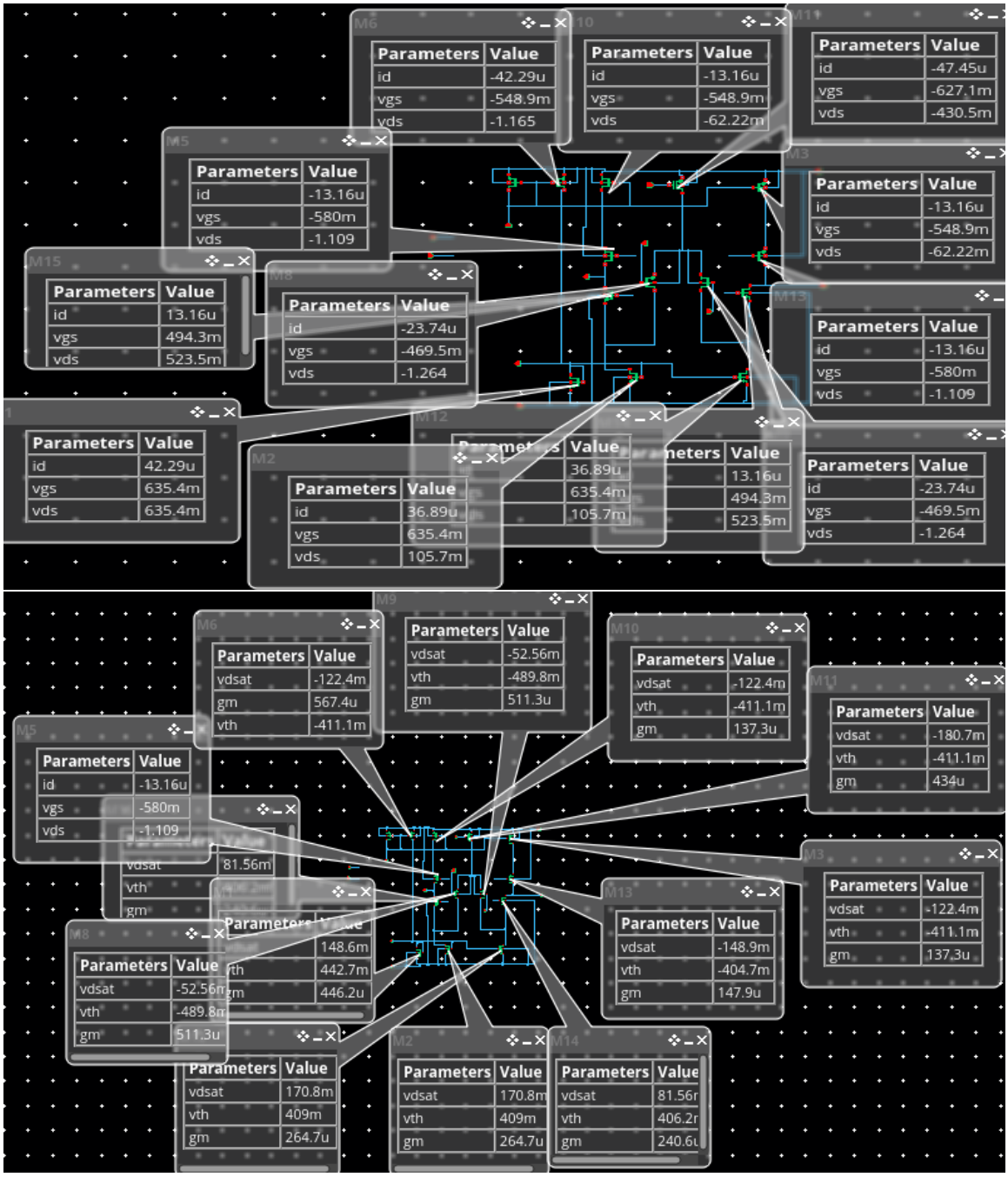
-VCASCN ≈ VGSN + V* = 688.3m + .1333 = .689

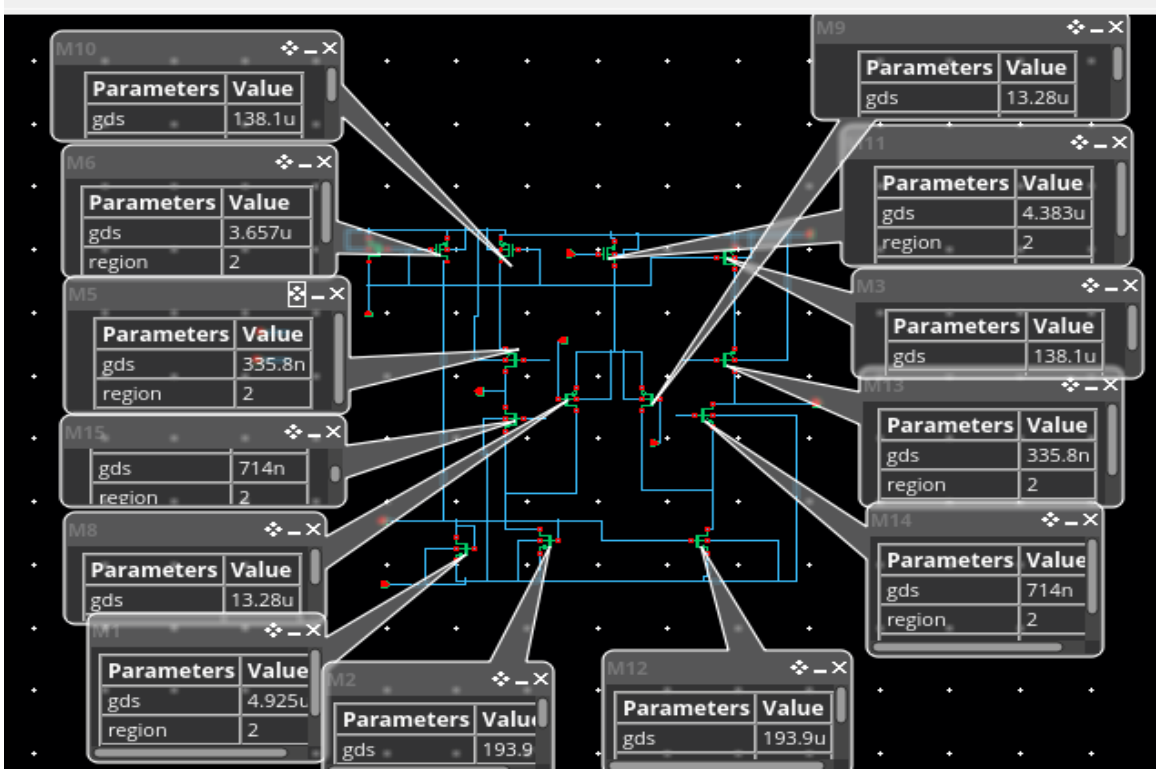
-VCASCP ≈ VDD - |VGSP| - V*=1.8-.6744-.1333 =1.157

PART 3: Open-Loop OTA Simulation (Behavioral CMFB)



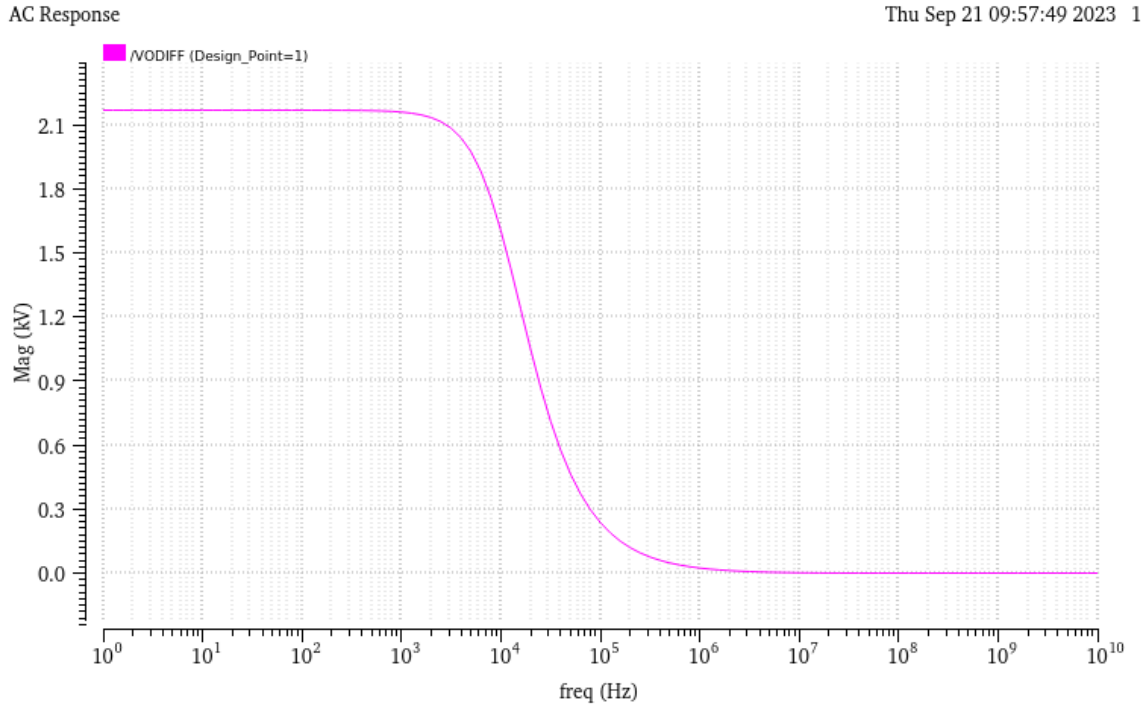
1)

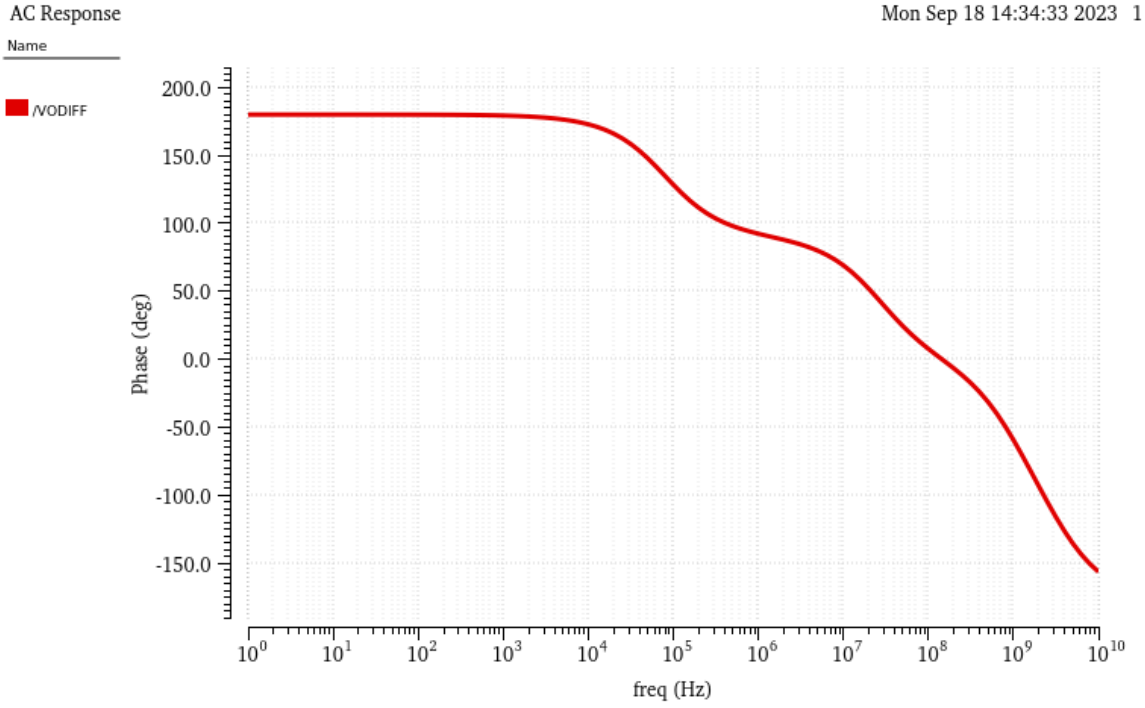

M6
Parameters Value
id -42.29u
vgs -548.9m
vds -1.165
10
Parameters Value
id -13.16u
vgs -548.9m
vds -62.22m
M11
Parameters Value
id -47.45u
vgs -627.1m
vds -430.5m
M5
Parameters Value
id -13.16u
vgs -580m
vds -1.109
M3
Parameters Value
id -13.16u
vgs -548.9m
vds -62.22m
M15
Parameters Value
id 13.16u
vgs 494.3m
vds 523.5m
M8
Parameters Value
id -23.74u
vgs -469.5m
vds -1.264
M13
Parameters Value
id -13.16u
vgs -580m
vds -1.109
Parameters Value
id 42.29u
vgs 635.4m
vds 635.4m
M12
M2
Parameters Value
id 36.89u
vgs 635.4m
vds 105.7m
Parameters Value
id -23.74u
vgs -469.5m
vds -1.264
M9
M6
Parameters Value
vdsat -122.4m
gm 567.4u
vth -411.1m
Parameters Value
vdsat -52.56m
vth -489.8m
gm 511.3u
M10
Parameters Value
vdsat -122.4m
vth -411.1m
gm 137.3u
M11
Parameters Value
vdsat -180.7m
vth -411.1m
gm 434u
M5
Parameters Value
id -13.16u
vgs -580m
vds -1.109
M3
Parameters Value
vdsat -122.4m
vth -411.1m
gm 137.3u
M13
Parameters Value
vdsat -148.9m
vth -404.7m
gm 147.9u
M8
Parameters Value
vdsat -52.56m
vth -489.8m
gm 511.3u
M2
Parameters Value
vdsat 170.8m
vth 409m
gm 264.7u
M14
Parameters Value
vdsat 81.56m
vth 406.2m
gm 240.6u

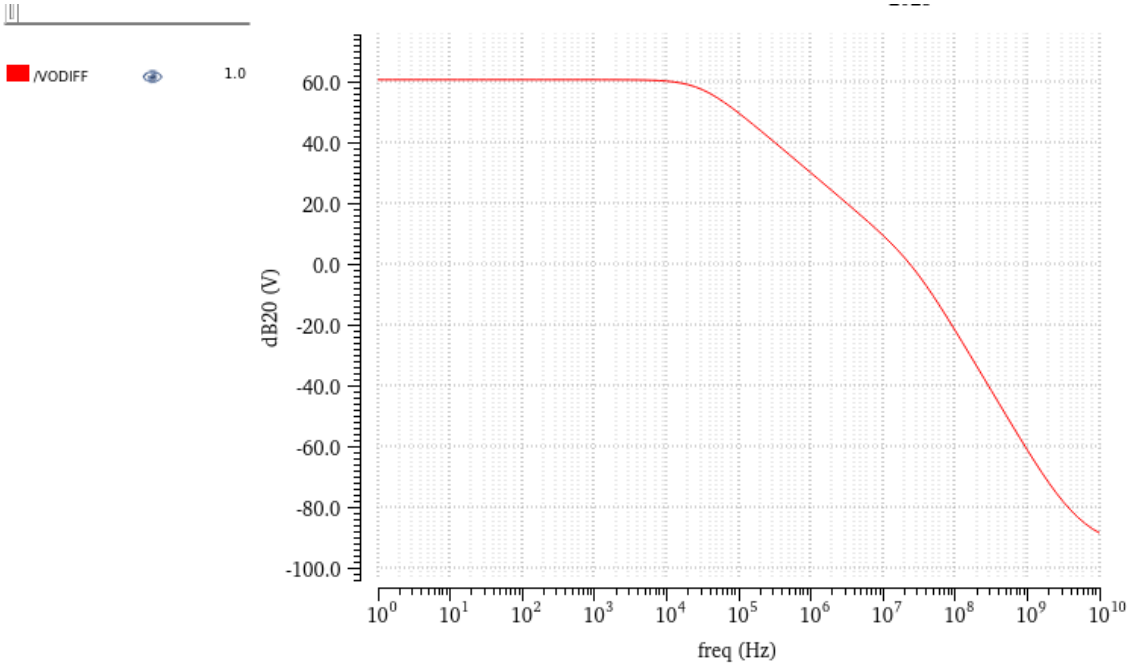


• VOCM = vdd-|vds1|-|vds2| = 513mv

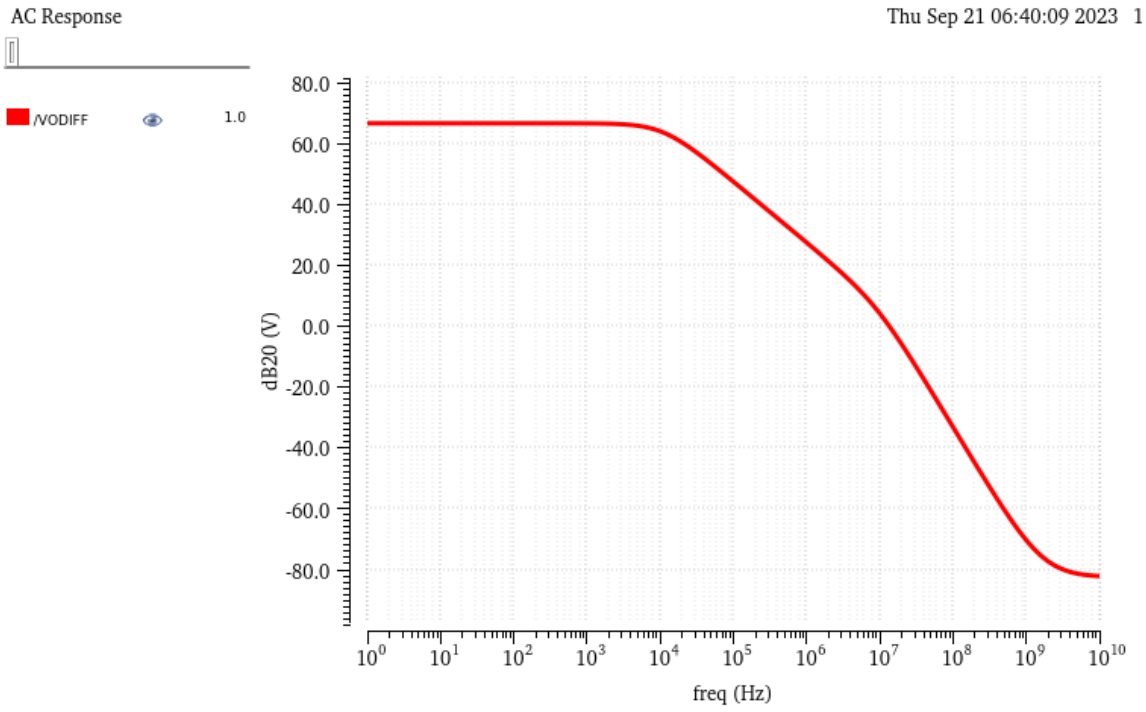
2)


AC Response
Thu Sep 21 09:57:49 2023 1
/VODIFF (Design_Point=1)
Mag (kV)
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
freq (Hz)


AC Response
Mon Sep 18 14:34:33 2023 1
Name
/VODIFF
Phase (deg)
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
freq (Hz)



And then to increase the gain we will raise the width of the cascade to meet the specs the new gain will be



GBW	23.92M
Fu	13.69M
BW	11.07K
Ao_dB	66.67

Gain = -gm0 * (gm1*ro^2)/4 =2942 ,in db = 69.3 dB

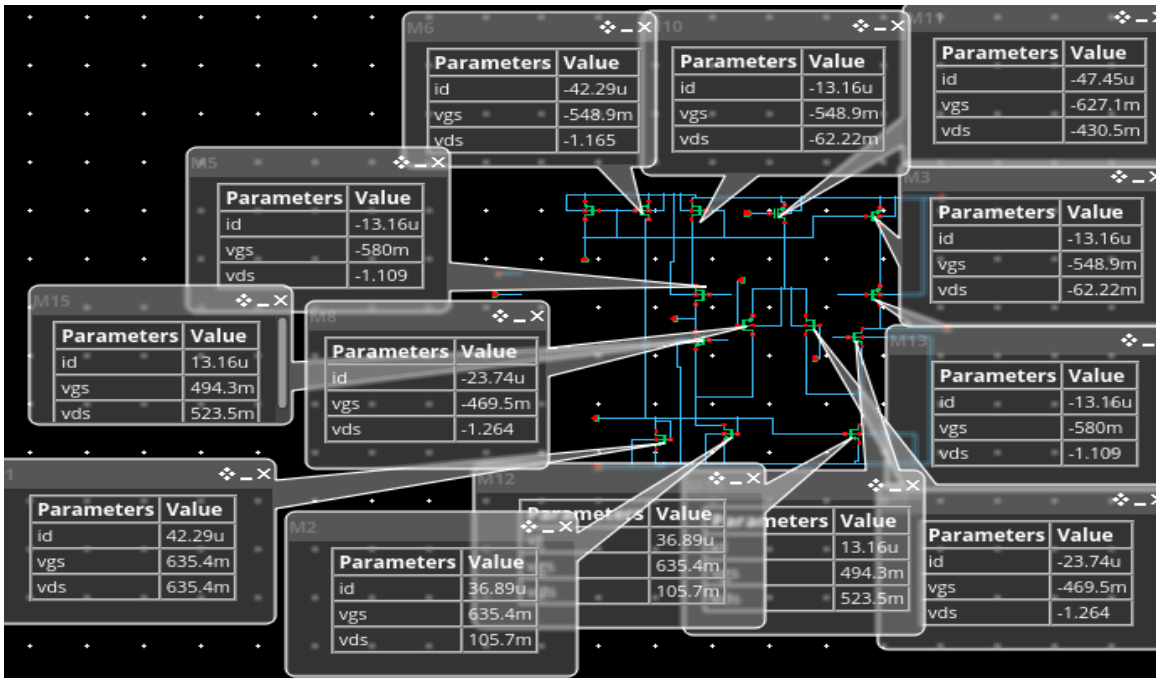
BW = 1/Rout *C = 13 k

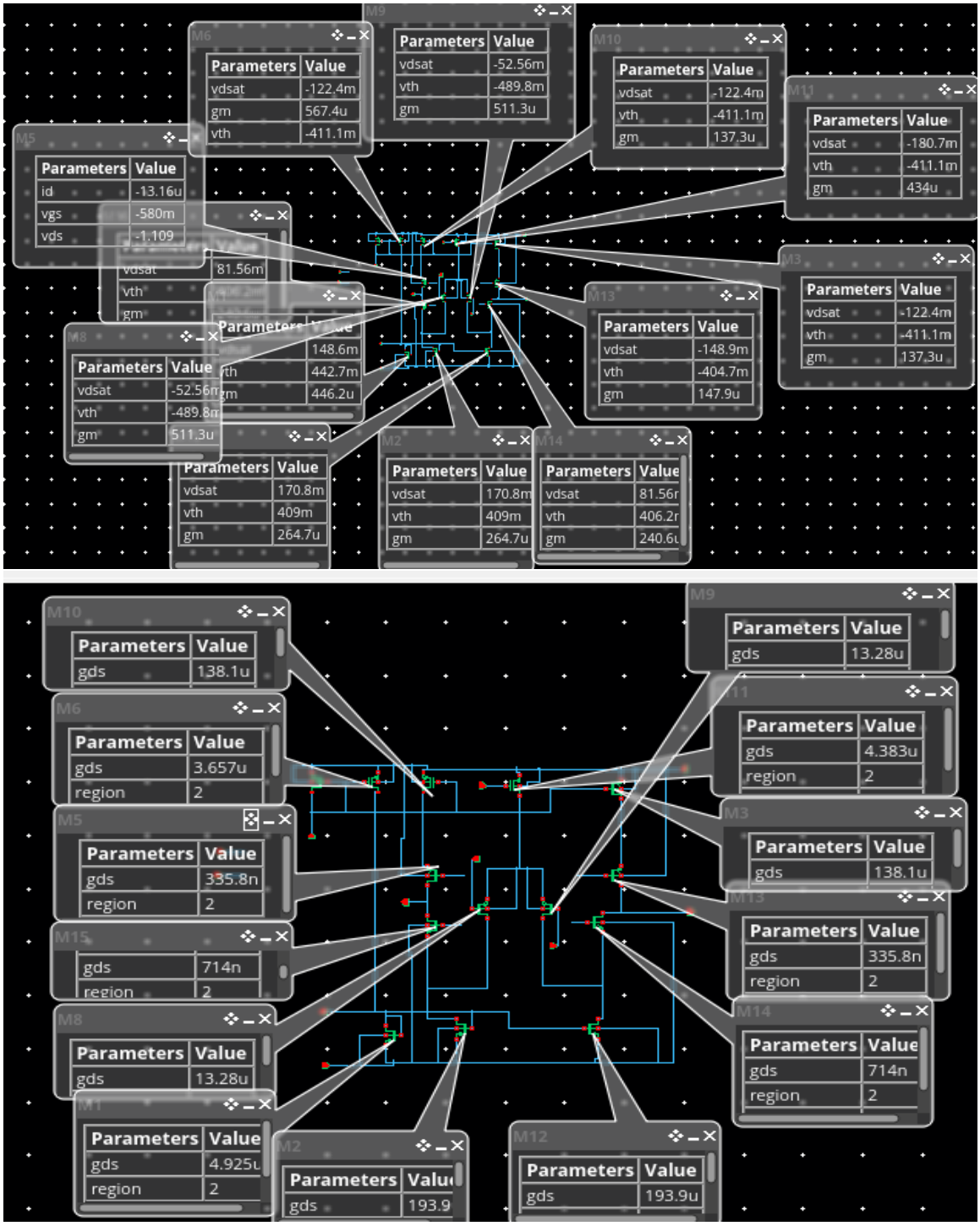
UGF=GBW = gm0/Cl = 25.8MHz

	simulation	Hand analysis
GBW	23.92M	25.8M
Fu	13.69M	25.8M
BW	11.07K	13k
Ao_dB	66.67	69.3
A0	2450	2942

PART 4: Open-Loop OTA Simulation (Actual CMFB)

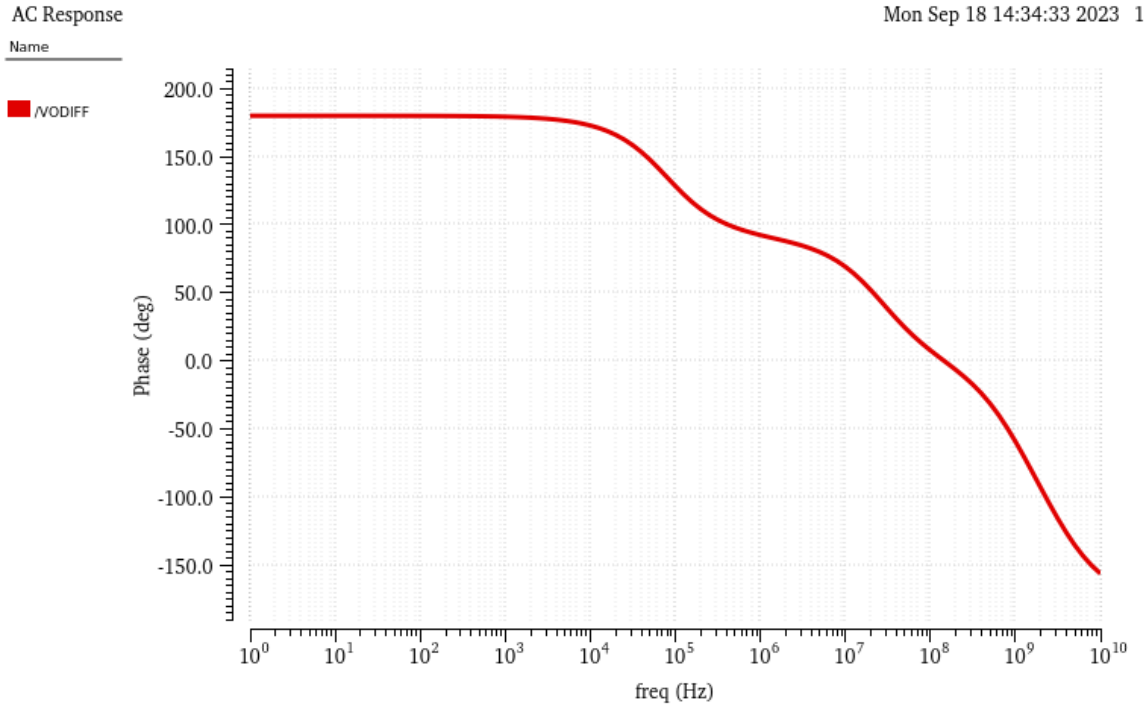
1)

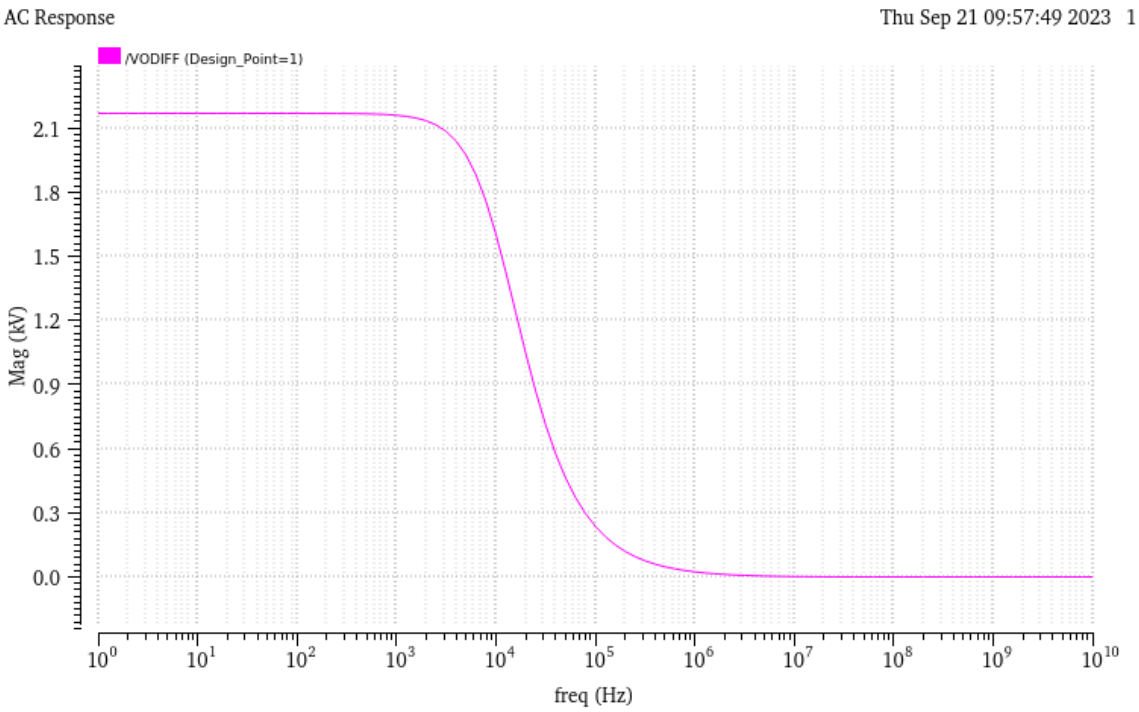

M6
Parameters Value
id -42.29u
vgs -548.9m
vds -1.165
M10
Parameters Value
id -13.16u
vgs -548.9m
vds -62.22m
M11
Parameters Value
id -47.45u
vgs -627.1m
vds -430.5m
M5
Parameters Value
id -13.16u
vgs -580m
vds -1.109
M3
Parameters Value
id -13.16u
vgs -548.9m
vds -62.22m
M15
Parameters Value
id 13.16u
vgs 494.3m
vds 523.5m
M8
Parameters Value
id -23.74u
vgs -469.5m
vds -1.264
M13
Parameters Value
id -13.16u
vgs -580m
vds -1.109
Parameters Value
id 42.29u
vgs 635.4m
vds 635.4m
M12
Value
36.89u
635.4m
105.7m
M2
Parameters Value
id 36.89u
vgs 635.4m
vds 105.7m
Value
13.16u
494.3m
523.5m
Parameters Value
id -23.74u
vgs -469.5m
vds -1.264

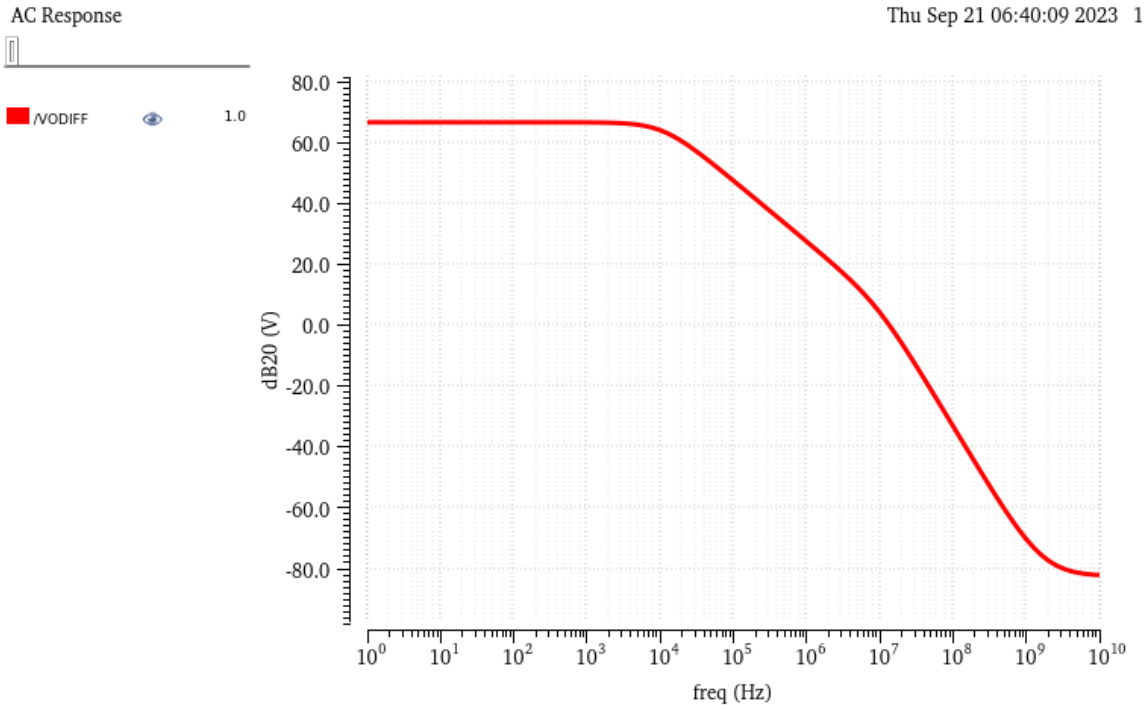


-CM output = 1.8+vds1 + vds2 = .628

2)

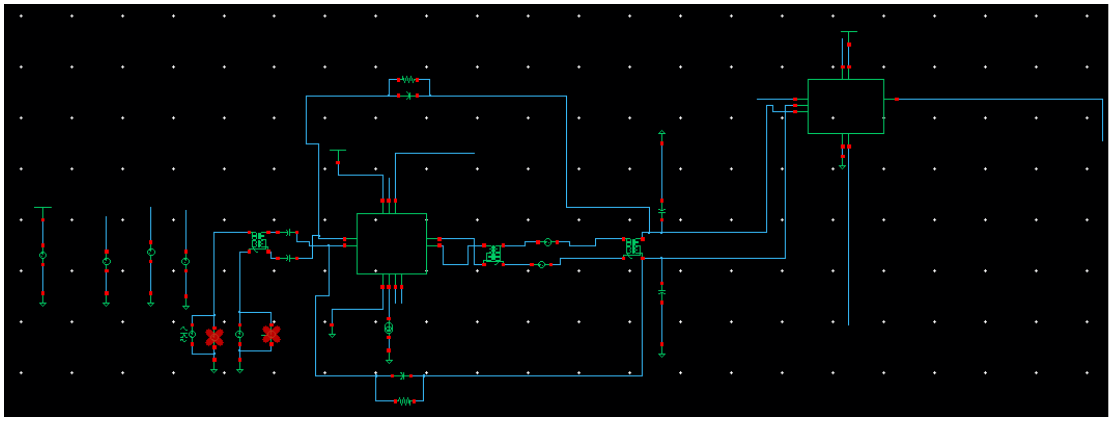

AC Response
Mon Sep 18 14:34:33 2023 1
Name
/VODIFF
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
Phase (deg)
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
freq (Hz)

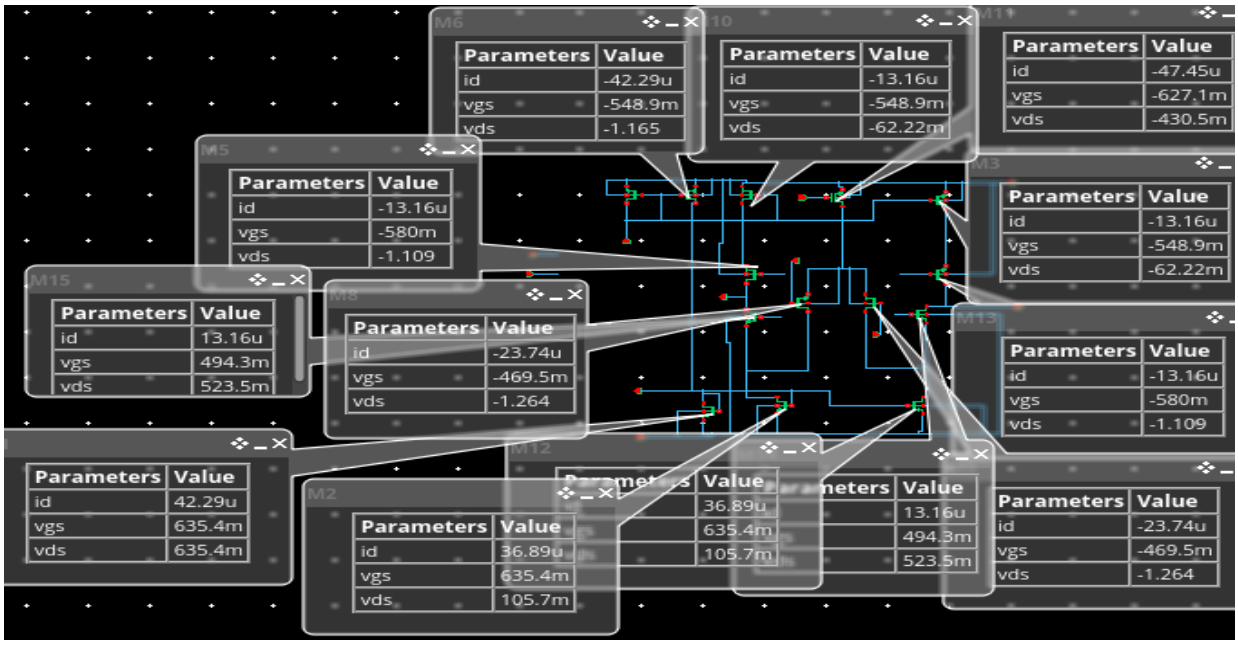




GBW	23.92M
Fu	13.69M
BW	11.07K
PM	-146.1
Ao_dB	66.67

PART 5: Closed Loop Simulation (AC and STB Analysis)

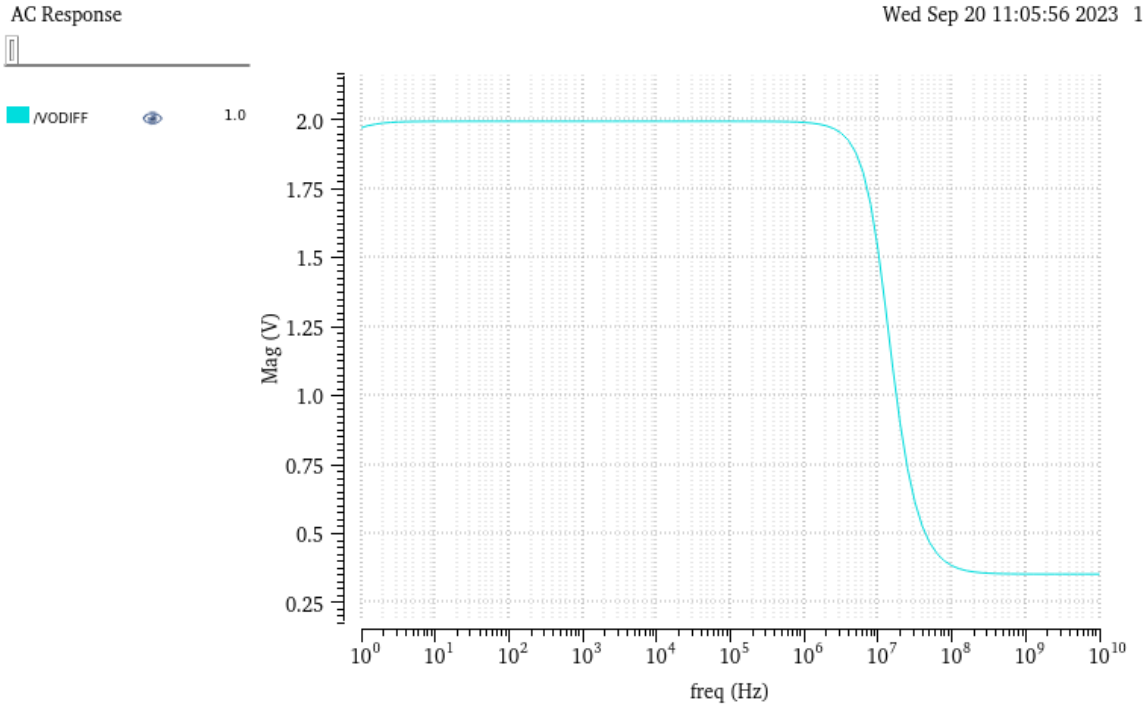


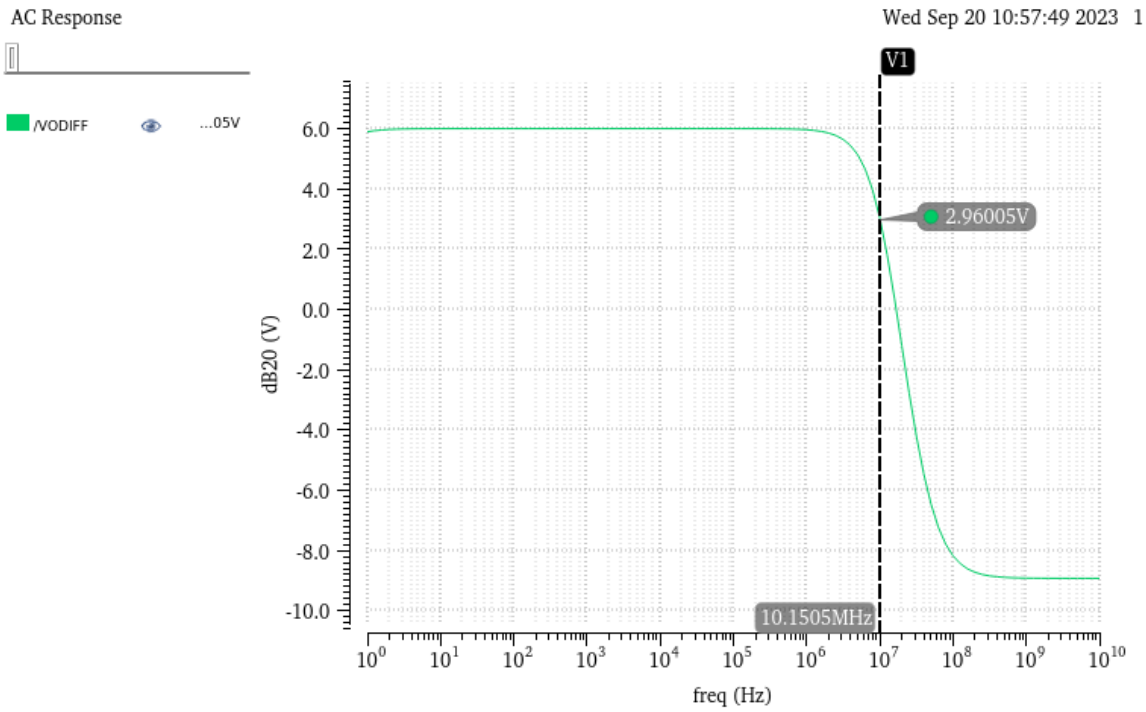


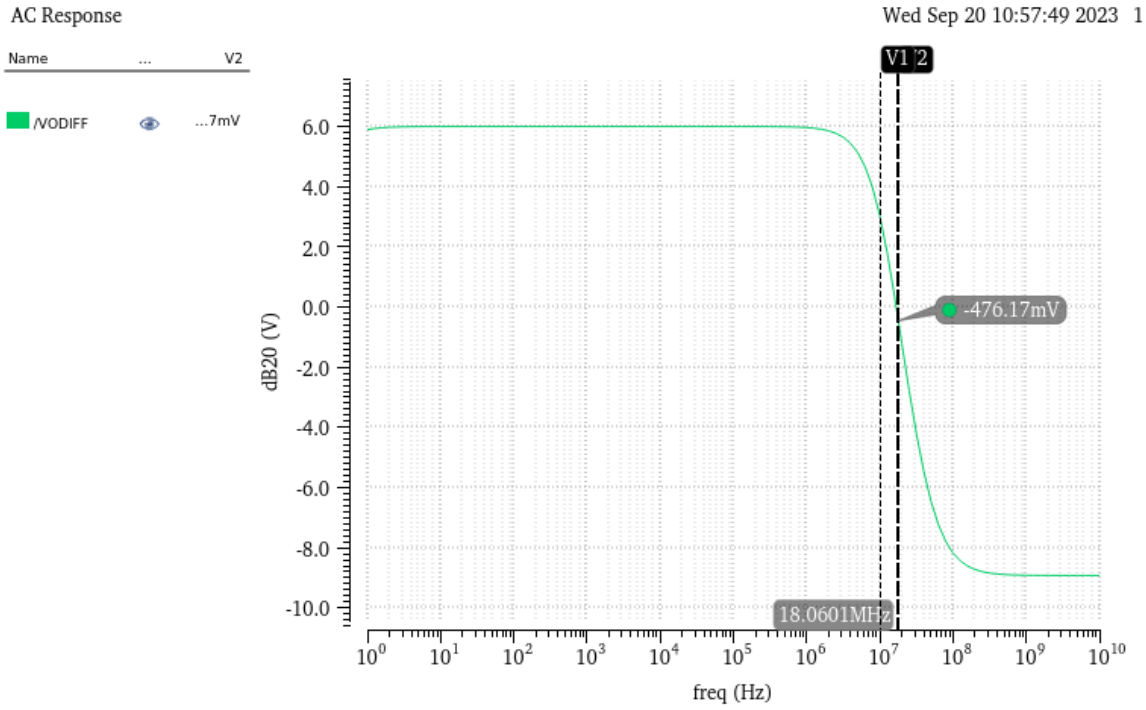
-CM level at the OTA output is 810 mV; 1.8- vds1- vds2 = 810 m

-CM level at the OTA input is 1.8-vsg – vds =607 mV

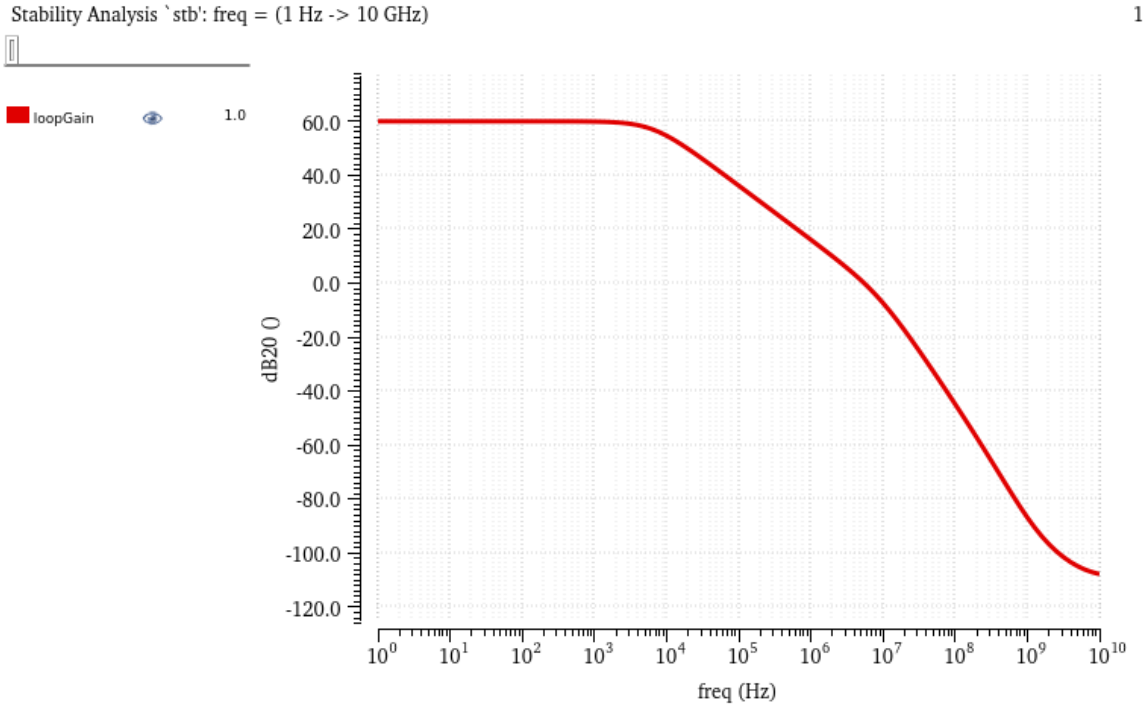
2)

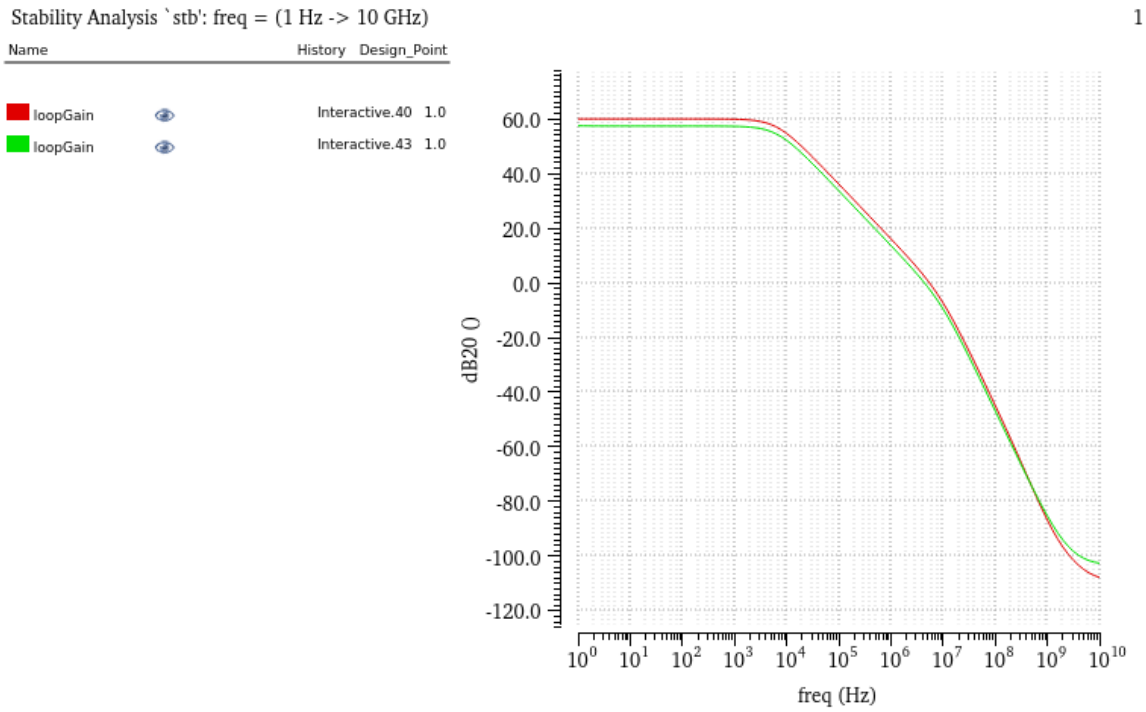

AC Response
Wed Sep 20 11:05:56 2023 1
/VODIFF
1.0
2.0
1.75
1.5
1.25
1.0
0.75
0.5
0.25
Mag (V)
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
freq (Hz)

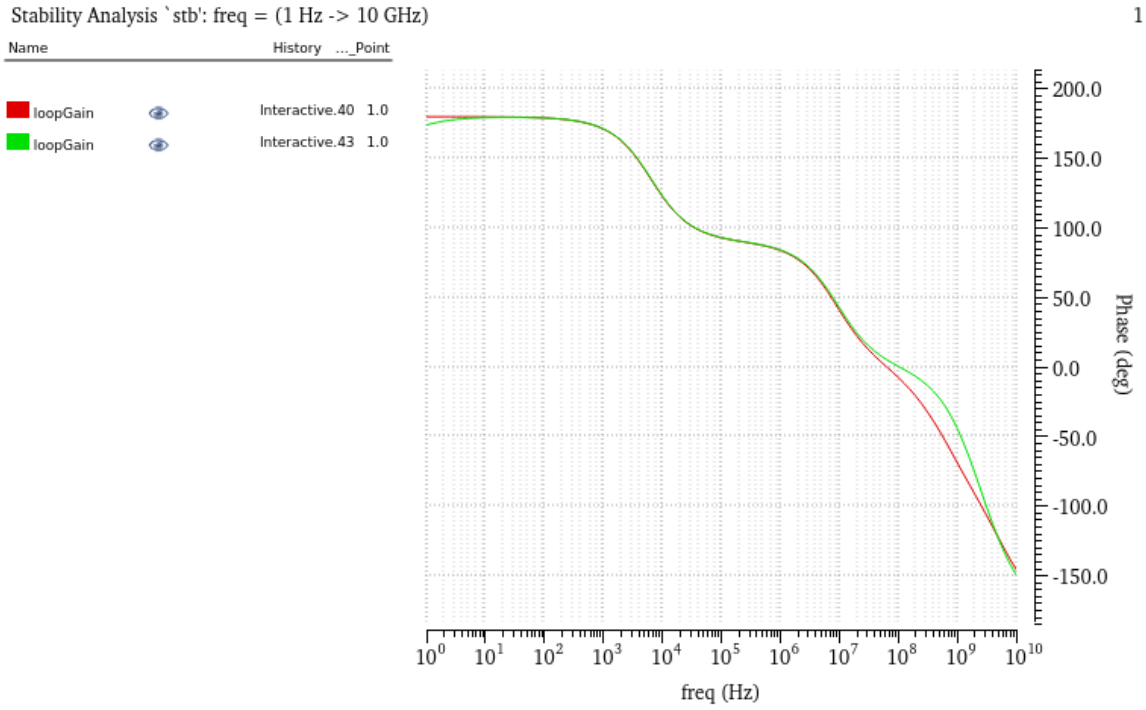

AC Response
Wed Sep 20 10:57:49 2023 1
/VODIFF
...05V
V1
2.96005V
10.1505MHz
dB20 (V)
freq (Hz)


AC Response
Wed Sep 20 10:57:49 2023 1
Name
...
V2
/VODIFF
...7mV
V1
V2
-476.17mV
18.0601MHz
dB20 (V)
freq (Hz)

3)


Stability Analysis `stb': freq = (1 Hz -> 10 GHz)
1
loopGain
1.0
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
-120.0
dB20 ()
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
freq (Hz)



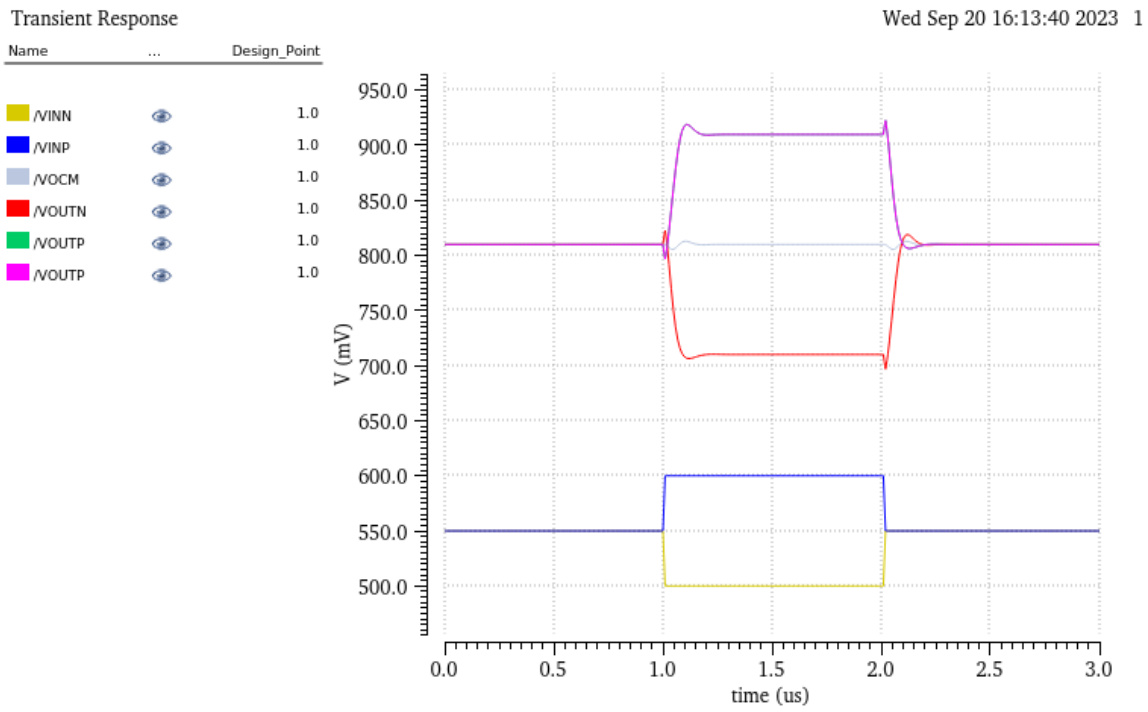


LG = B*AoL=1/3 AOL

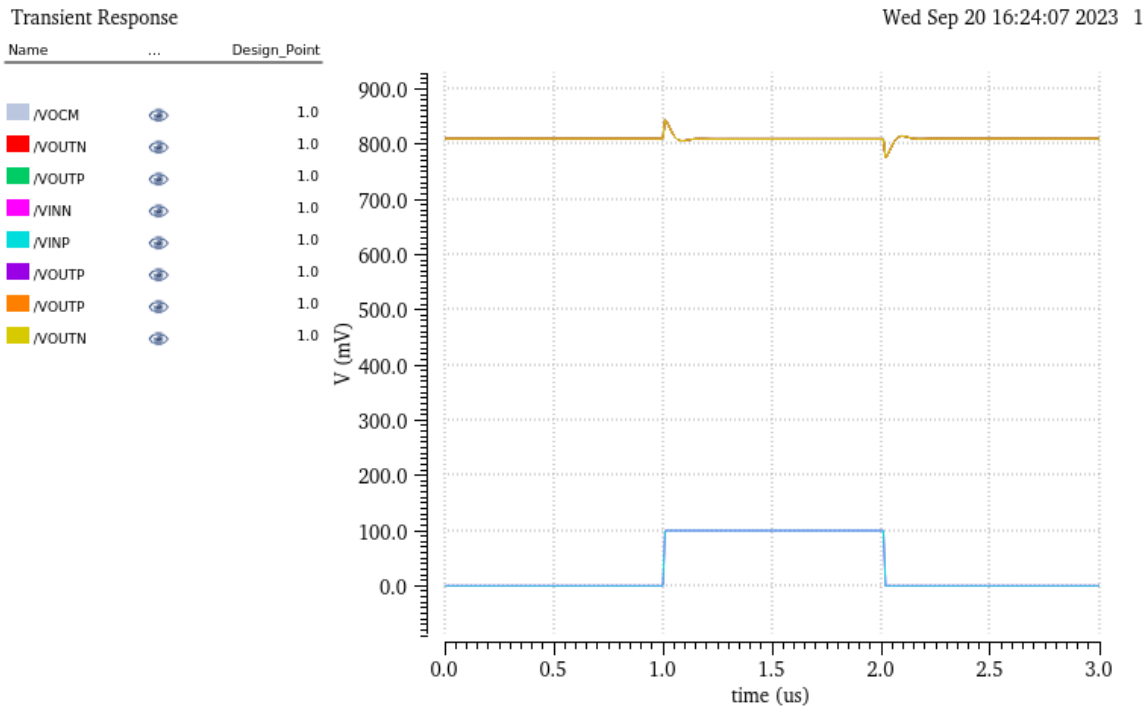
B= Z2/(Z1+Z2)

PART 6: Closed Loop Simulation (Transient Analysis)

1)

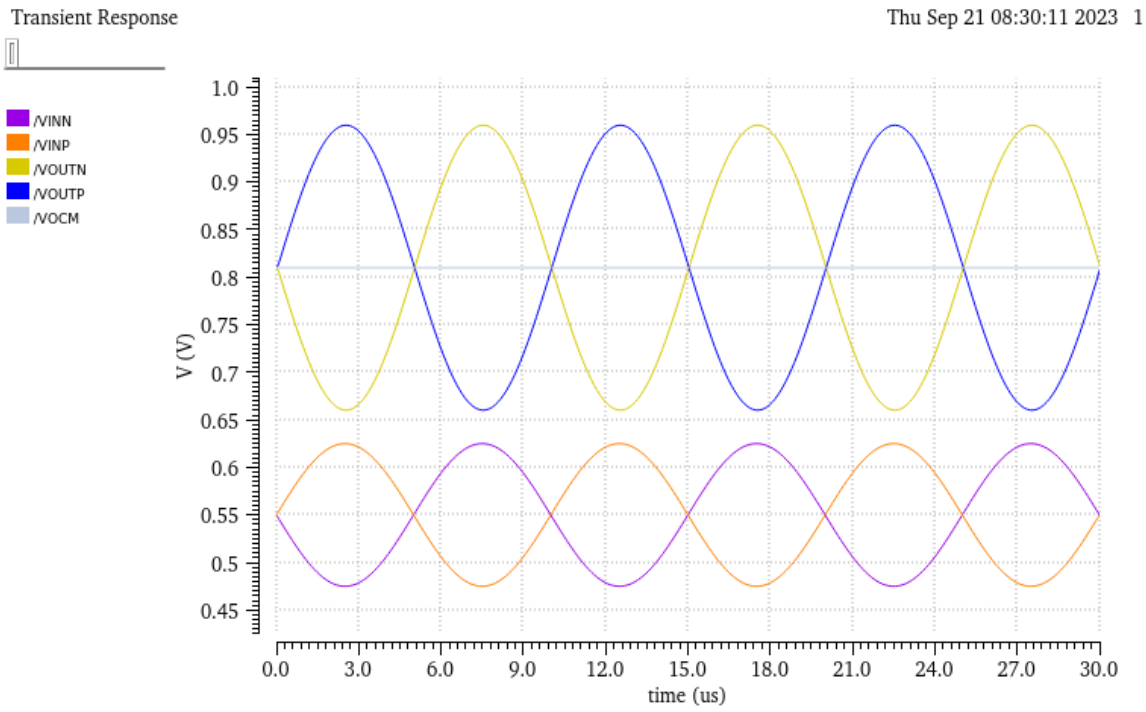


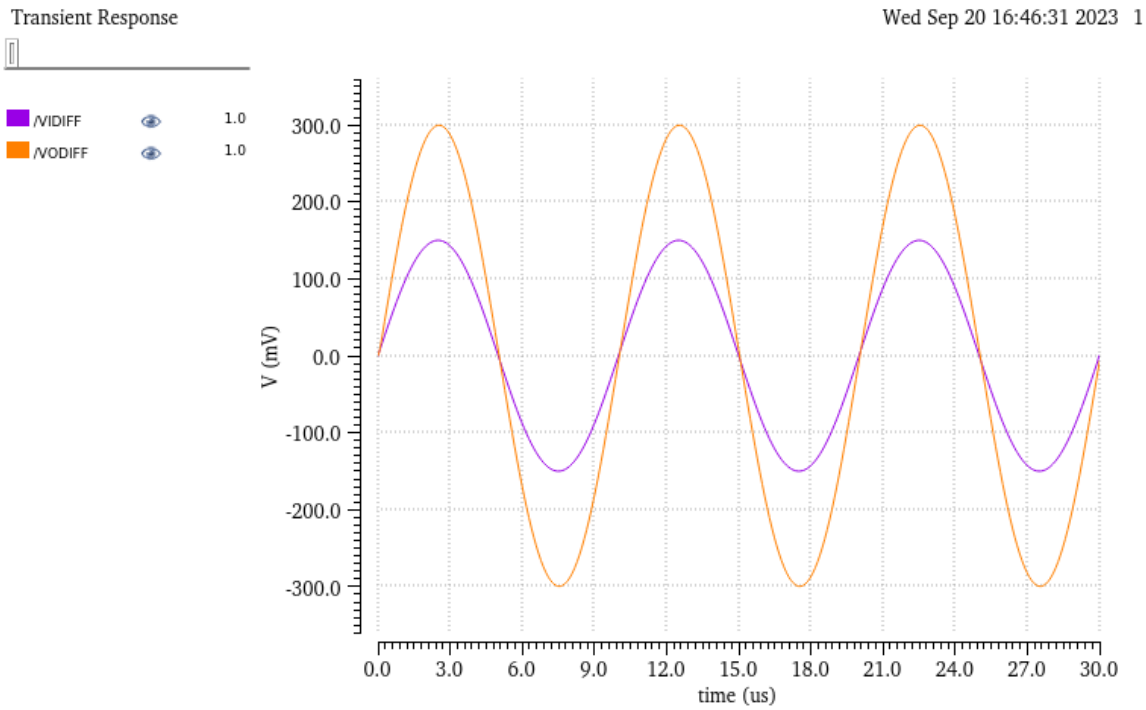
There is a small ringing in the beginning and the loops are stable with adequate PM .

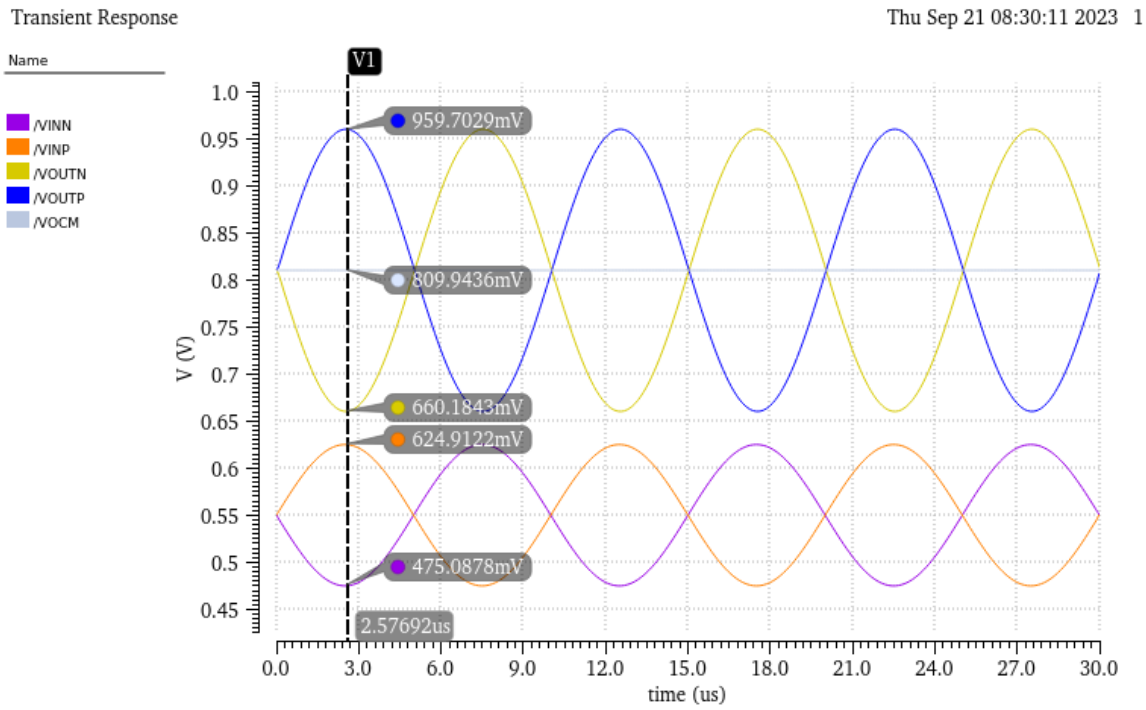


There is a small ringing in the beginning and the loops are stable with adequate PM.

2)


Transient Response
Thu Sep 21 08:30:11 2023 1
/VINN
/VINP
/VOUTN
/VOUTP
/VOCM
1.0
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
V (V)
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
27.0
30.0
time (us)





input peak to peak swing = 625m-475m = 150m v

Output peak to peak swing = (960m-660m) =300mv

Closed loop gain = (960m-660m)/(625m-475m) = 2.

	Expression	Value	Expression	Value
1	gainBwProd(leaf...	4.800E6	phaseMargin(le...	180.0

	Expression	Value	Expression	Value
1	phaseMargin(le...	180.0	gainBwProd(leaf...	6.450E6