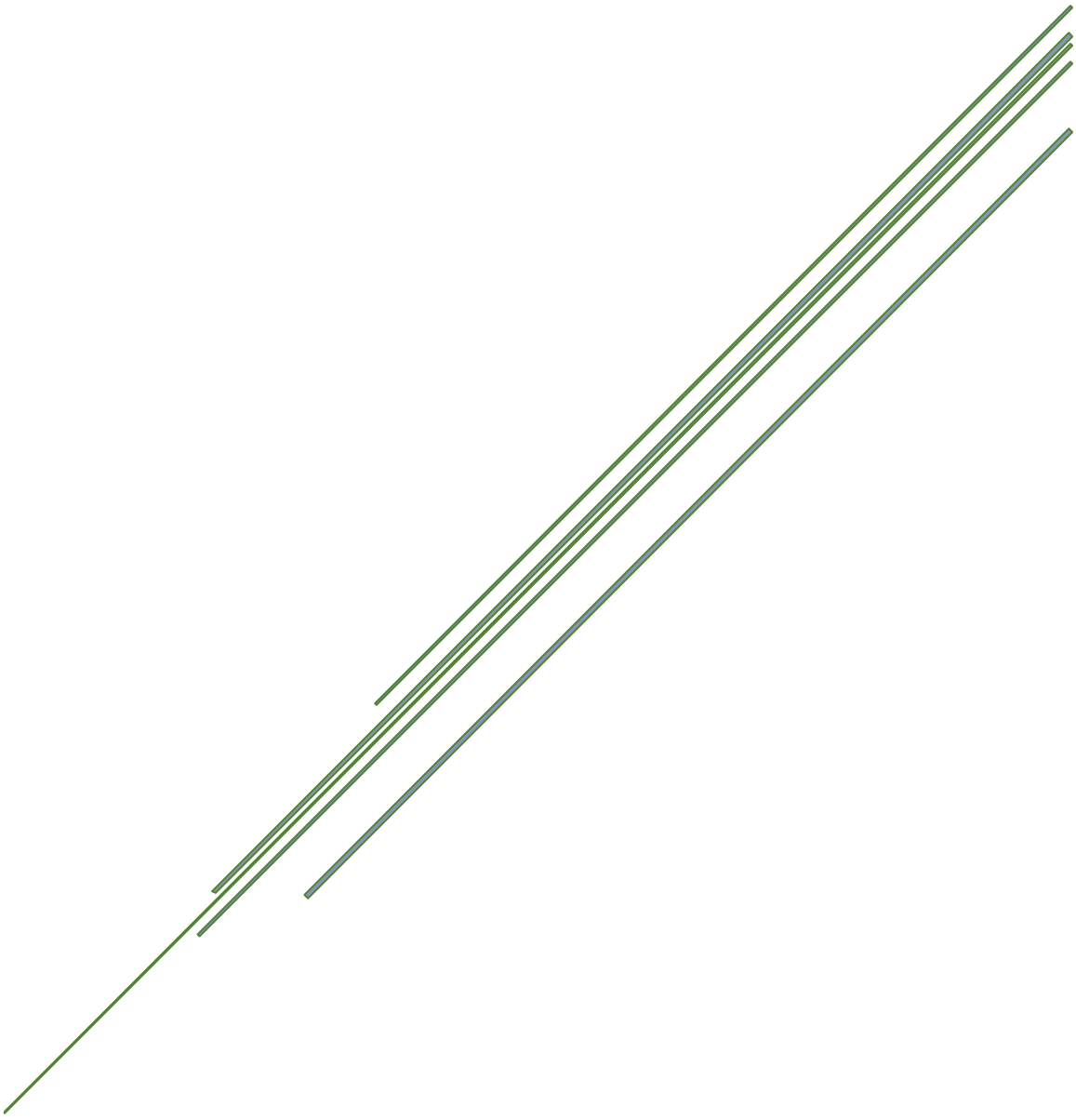
EEE 230 PROJECT-2 REPORT

DESIGN AN OPERATIONAL AMPLIFIER



AIM

The main objective of the project is to design and simulate a CMOS operational amplifier with the following set of required specifications.

Required Opamp Specifications:

1. DC open loop voltage gain > 60dB
2. Unity Gain Bandwidth > 200 MHz
3. Phase margin between 70 and 75 degrees at unity gain
4. Vout swing > 400mVp-p (single-ended)
5. Common-mode input voltage range must go down to at least .8V, and up to at least 1V
6. Load capacitance = 1 pF
7. Minimum Von for all saturated FETs = 100 mV
8. Process technology = 0.13µm CMOS
9. Supply voltages are VDD = 1.2V and VSS = 0V (ground)
10. Temperature = 27° C

Introduction

There are various Op-Amp topologies studied to achieve tradeoffs to design Op-Amp with the required specifications. The Wide Swing Folded Cascoded Op-Amp topology with NMOS input stage was chosen to meet the wider Common-Mode Input Range and the wider output swing with a low power supply. There are a few other factors that provided strong support for this topology such as controls frequency behavior, and maximum Bandwidth if needed.

The formulas to achieve desired specifications for hand calculations:

1. DC Open Loop Voltage Gain:
   $A_{dm} = \alpha * g_{m1} * R_{out}$
   $\alpha = ro_6 / ro_6 + R_{is4}$
   $R_{out} = [\ ro_4\ (1+ g_{m4}\ (ro_2 \,||\, ro_6))\ ] \,||\, [ro_8\ (1+ g_{m8} * ro_{10})]$
   $= \mu_{f4}\ (ro_2 \,||\, ro_6) \,||\, \mu_{f8} * ro_{10}$

2. Unity Gain Bandwidth:
   $UGB = gm_1 / 2\pi * C_L$

3. Phase Margin:
   $PM = \angle a(j\omega) + 180°$

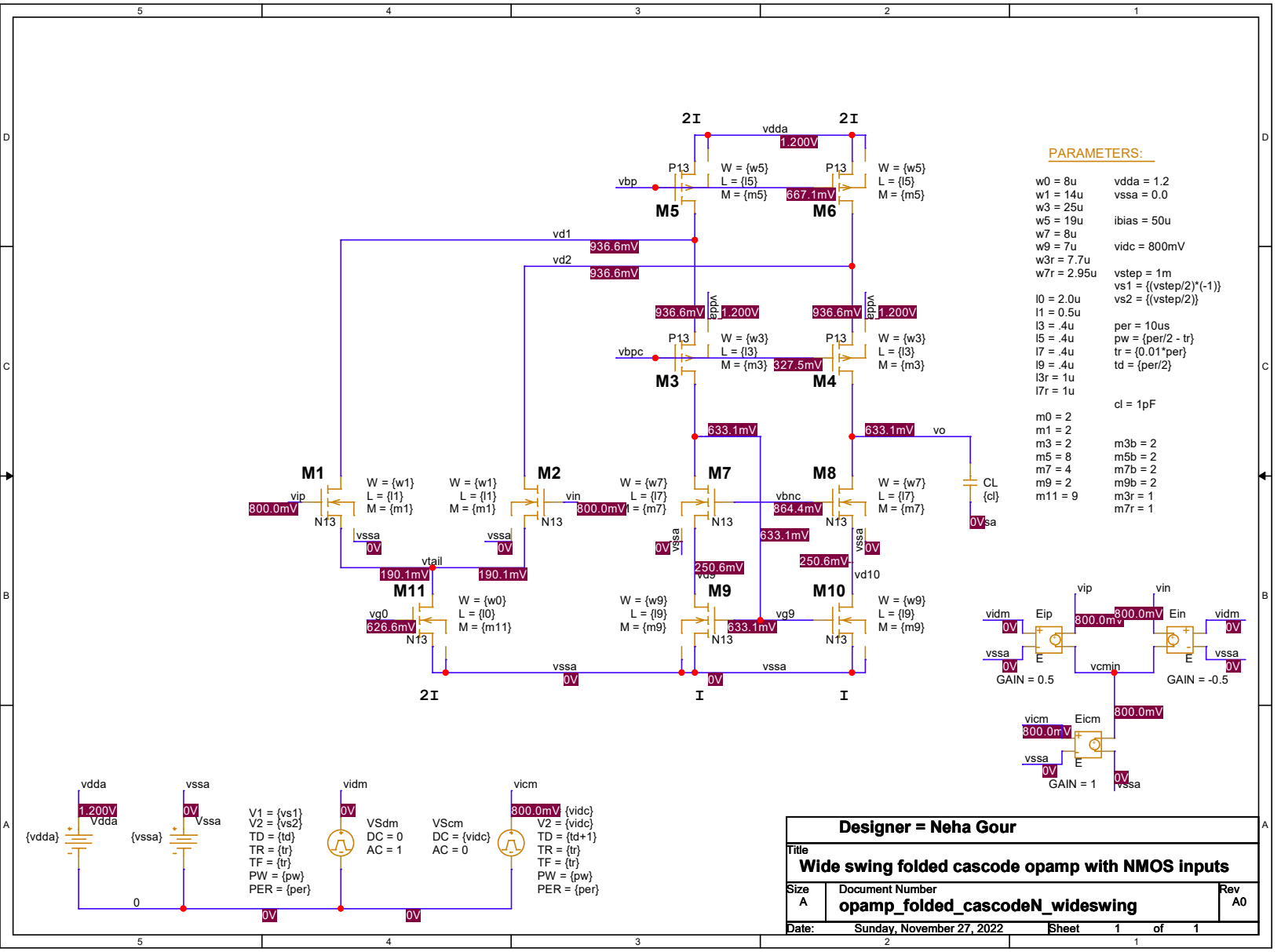
4. V_{out} Swing:
   $V_{o\,(min)} = V_{GS10} + V_{ov8}$
   $V_{o(max)} = V_{bpc} + |V_{t4}|$

   Where,

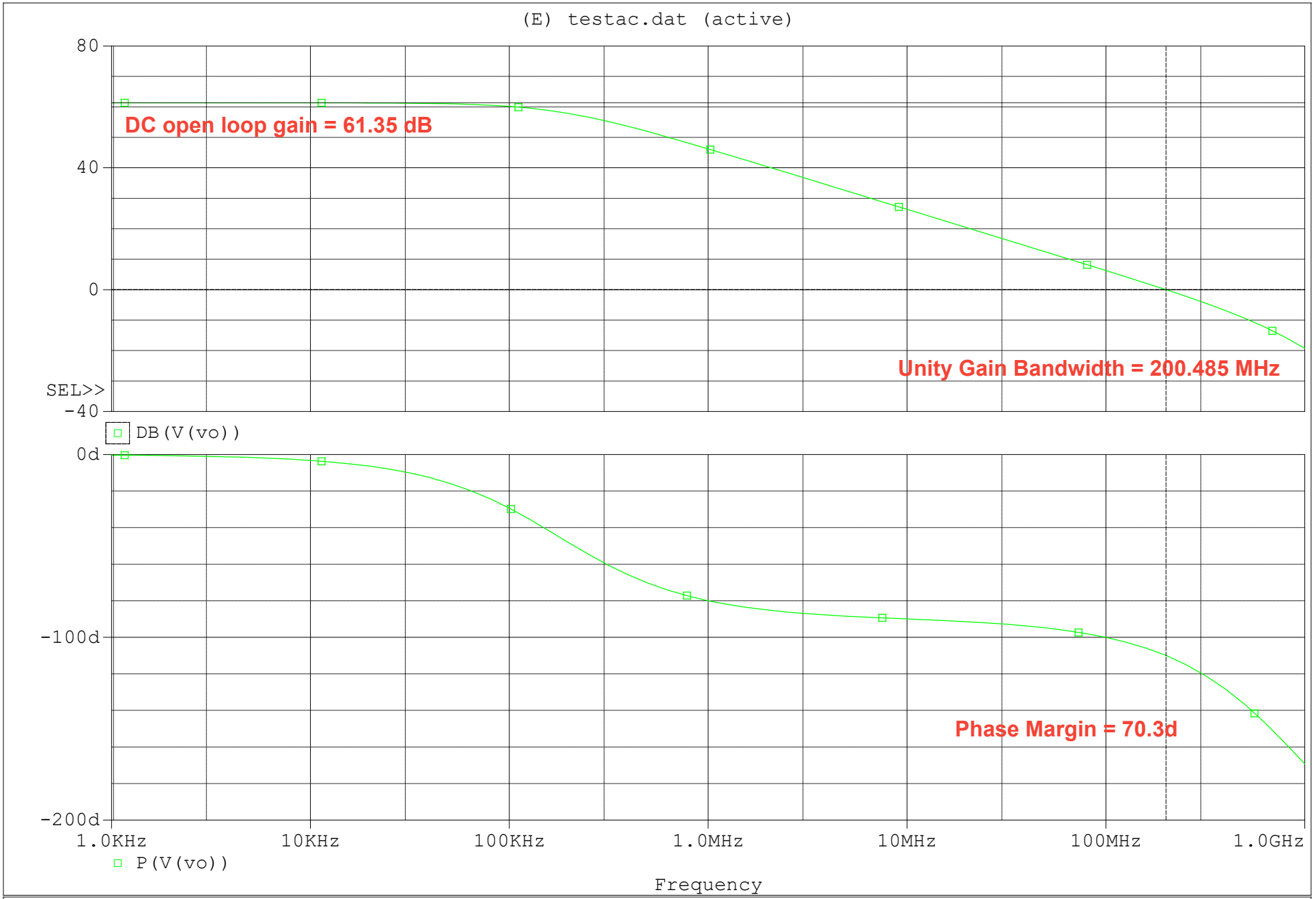
   PM - Phase Margin
   A_{dm} - Open loop gain
   R_{out} - Output Resistance
   UGB - Unity Gain Bandwidth
   $V_{o(min)}$ - Minimum Output value
   $V_{o(max)}$ - Maximum Output value

COMMON-MODE INPUT VOLTAGE
(V_{ICM} = .8 V)

DC Open-loop Voltage Gain,
Unity Gain Bandwidth
Phase Margin

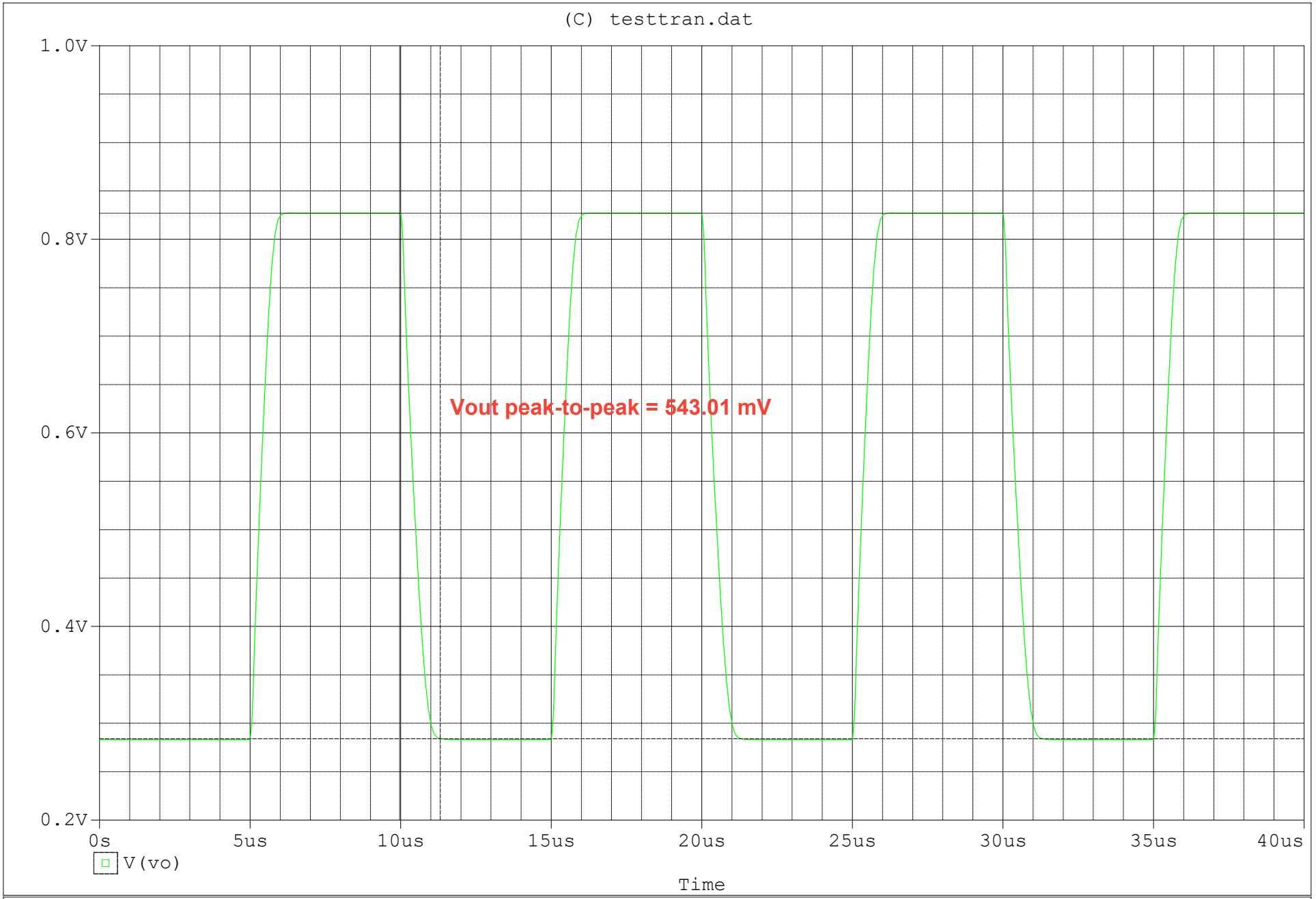

2I
vdda
1.200V
2I
P13
W = {w5}
L = {l5}
M = {m5}
vbp
667.1mV
M5
M6
vd1
936.6mV
vd2
936.6mV
vbpc
327.5mV
M3
M4
M1
M2
M7
M8
vip
800.0mV
vin
800.0mV
vbnc
864.4mV
633.1mV
vo
CL
{cl}
vtail
190.1mV
M11
M9
M10
vg0
626.6mV
vg9
633.1mV
vd10
250.6mV
vssa
0V
I
I
PARAMETERS:
w0 = 8u
w1 = 14u
w3 = 25u
w5 = 19u
w7 = 8u
w9 = 7u
w3r = 7.7u
w7r = 2.95u
l0 = 2.0u
l1 = 0.5u
l3 = .4u
l5 = .4u
l7 = .4u
l9 = .4u
l3r = 1u
l7r = 1u
m0 = 2
m1 = 2
m3 = 2
m5 = 8
m7 = 4
m9 = 2
m11 = 9
vdda = 1.2
vssa = 0.0
ibias = 50u
vidc = 800mV
vstep = 1m
vs1 = {(vstep/2)*(-1)}
vs2 = {(vstep/2)}
per = 10us
pw = {per/2 - tr}
tr = {0.01*per}
td = {per/2}
cl = 1pF
m3b = 2
m5b = 2
m7b = 2
m9b = 2
m3r = 1
m7r = 1
vidm
Eip
Ein
vcmin
GAIN = 0.5
GAIN = -0.5
vicm
Eicm
GAIN = 1
{vdda}
{vssa}
V1 = {vs1}
V2 = {vs2}
TD = {td}
TR = {tr}
TF = {tr}
PW = {pw}
PER = {per}
VSdm
DC = 0
AC = 1
VScm
DC = {vidc}
AC = 0
V2 = {vidc}+1
0
Designer = Neha Gour
Title
Wide swing folded cascode opamp with NMOS inputs
Size
A
Document Number
opamp_folded_cascodeN_wideswing
Rev
A0
Date:
Sunday, November 27, 2022
Sheet
1
of
1

** Profile: "SCHEMATIC1-testac" [u:\desktop\230\project_2\opamp_folded_cascoden_wideswing\opamp_folded...
Date/Time run: 11/27/22 22:09:45 Temperature: 27.0



E1:(1.0243K,61.354) E2:(200.486M,47.298m) DIFF(E):(-200.485M,61.307)

** Profile: "SCHEMATIC1-testtran" [u:\desktop\230\project_2\opamp_folded_cascoden_wideswing\opamp_fold...
Date/Time run: 11/27/22 22:07:33 Temperature: 27.0



C1:(9.966u,827.065m) C2:(11.310u,284.046m) DIFF(C):(-1.3448u,543.019m)
Date: November 27, 2022 Page 1 Time: 22:29:09

```
 1: □
 2: **** 11/27/22 22:09:45 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********
 3:
 4:  ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
    wing\opamp_folded_cascoden_wideswing\opamp_fo
 5:
 6:
 7:  ****     CIRCUIT DESCRIPTION
 8:
 9:
10: ********************************************************************************
11:
12:
13:
14:
15: ** Creating circuit file "testac.cir"
16: ** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIO
    NS
17:
18: *Libraries:
19: * Profile Libraries :
20: * Local Libraries :
21: .LIB "../../../opamp_folded_cascoden_wideswing-pspicefiles/opamp_folded_cascoden_wideswi
    ng.lib"
22: * From [PSPICE NETLIST] section of U:\cdssetup\OrCAD_PSpice\17.4.0\PSpice.ini file:
23: .lib "nom.lib"
24:
25: *Analysis directives:
26: .AC DEC 10 1k 1g
27: .OP
28: .OPTIONS ADVCONV
29: .OPTIONS NUMDGT= 5
30: .OPTIONS RELTOL= 0.0001
31: .PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
32: .INC "..\SCHEMATIC1.net"
33:
34:
35:
36: **** INCLUDING SCHEMATIC1.net ****
37: * source OPAMP_FOLDED_CASCODEN_WIDESWING
38: M_M1          VD1 VIP VTAIL VSSA N13
39: + L={l1}
40: + W={w1}
41: + M={m1}
42: M_M2          VD2 VIN VTAIL VSSA N13
43: + L={l1}
44: + W={w1}
45: + M={m1}
46: M_M11          VTAIL VG0 VSSA VSSA N13
47: + L={l0}
48: + W={w0}
49: + M={m11}
50: M_M5          VD1 VBP VDDA VDDA P13
51: + L={l5}
52: + W={w5}
53: + M={m5}
54: V_Vdda          VDDA 0 {vdda}
55: V_Vssa          VSSA 0 {vssa}
56: C_CL          VSSA VO  {cl}  TC=0,0
57: M_M3          VG9 VBPC VD1 VDDA P13
58: + L={l3}
59: + W={w3}
60: + M={m3}
61: M_M6          VD2 VBP VDDA VDDA P13
62: + L={l5}
63: + W={w5}
64: + M={m5}
65: M_M4          VO VBPC VD2 VDDA P13
66: + L={l3}
67: + W={w3}
68: + M={m3}
```

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 69: M_M8         VO VBNC VD10 VSSA N13
 70: + L={l7}
 71: + W={w7}
 72: + M={m7}
 73: M_M7         VG9 VBNC VD9 VSSA N13
 74: + L={l7}
 75: + W={w7}
 76: + M={m7}
 77: M_M10         VD10 VG9 VSSA VSSA N13
 78: + L={l9}
 79: + W={w9}
 80: + M={m9}
 81: M_M9         VD9 VG9 VSSA VSSA N13
 82: + L={l9}
 83: + W={w9}
 84: + M={m9}
 85: M_M12         VBPC VG0 VSSA VSSA N13
 86: + L={l0}
 87: + W={w0}
 88: + M={m0}
 89: I_Ibias1         VDDA VG0 DC {ibias}
 90: M_M0         VG0 VG0 VSSA VSSA N13
 91: + L={l0}
 92: + W={w0}
 93: + M={m0}
 94: M_M3r         VD3R VBPC VDDA VDDA P13
 95: + L={l3r}
 96: + W={w3r}
 97: + M={m3r}
 98: M_M3b         VBPC VBPC VD3R VDDA P13
 99: + L={l3}
100: + W={w3}
101: + M={m3b}
102: M_M13         VBP VG0 VSSA VSSA N13
103: + L={l0}
104: + W={w0}
105: + M={m0}
106: M_M5b         VD5B VBP VDDA VDDA P13
107: + L={l5}
108: + W={w5}
109: + M={m5b}
110: M_M5bc         VBP VBPC VD5B VDDA P13
111: + L={l3}
112: + W={w3}
113: + M={m3b}
114: M_M14         VD14 VBP VDDA VDDA P13
115: + L={l5}
116: + W={w5}
117: + M={m5b}
118: M_M14c         VBNC VBPC VD14 VDDA P13
119: + L={l3}
120: + W={w3}
121: + M={m3b}
122: M_M15c         VBN VBPC VD15 VDDA P13
123: + L={l3}
124: + W={w3}
125: + M={m3b}
126: M_M15         VD15 VBP VDDA VDDA P13
127: + L={l5}
128: + W={w5}
129: + M={m5b}
130: M_M7r         VD7R VBNC VSSA VSSA N13
131: + L={l7r}
132: + W={w7r}
133: + M={m7r}
134: M_M7b         VBNC VBNC VD7R VSSA N13
135: + L={l7}
136: + W={w7}
137: + M={m7b}
138: M_M9b         VD9B VBN VSSA VSSA N13
139: + L={l9}
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140: + W={w9}
141: + M={m9b}
142: M_M9bc          VBN VBNC VD9B VSSA N13
143: + L={l7}
144: + W={w7}
145: + M={m7b}
146: E_Ein          VIN VCMIN VIDM VSSA -0.5
147: E_Eip          VIP VCMIN VIDM VSSA 0.5
148: E_Eicm          VCMIN VSSA VICM VSSA 1
149: V_VSdm          VIDM 0 DC 0 AC 1
150: +PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
151: V_VScm          VICM 0 DC {vidc} AC 0
152: +PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
153: .PARAM  l3=.4u l3r=1u m3r=1 w3=25u m9=2 vstep=1m per=10us cl=1pf l5=.4u vs1=
154: + {(vstep/2)*(-1)} w5=19u vs2={(vstep/2)} l7=.4u m7=4 m9b=2 vssa=0.0 w7=8u
155: +  vidc=800mv m5=8 m5b=2 m7b=2 w7r=2.95u ibias=50u l9=.4u m7r=1 m3=2 w9=7u m0=2
156: +  tr={0.01*per} td={per/2} vdda=1.2 m1=2 m11=9 l7r=1u w3r=7.7u pw={per/2 - tr}
157: +  w0=8u l1=0.5u w1=14u l0=2.0u m3b=2
158:
159: **** RESUMING testac.cir ****
160: .END
161:
162: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Pd = 0 is less than W
163:
164: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Ps = 0 is less than W
165:
166: WARNING(ORPSIM-15236): Parameter CTA in model N13 is invalid - Ignored
167:
168: WARNING(ORPSIM-15236): Parameter CTP in model N13 is invalid - Ignored
169:
170: WARNING(ORPSIM-15236): Parameter PTA in model N13 is invalid - Ignored
171:
172: WARNING(ORPSIM-15236): Parameter PTP in model N13 is invalid - Ignored
173:
174: WARNING(ORPSIM-15235): Mosfet M_M2, model N13: Pd = 0 is less than W
175:
176: WARNING(ORPSIM-15235): Mosfet M_M2, model N13: Ps = 0 is less than W
177:
178: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Pd = 0 is less than W
179:
180: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Ps = 0 is less than W
181:
182: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Pd = 0 is less than W
183:
184: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Ps = 0 is less than W
185:
186: WARNING(ORPSIM-15235): Mosfet M_M7, model N13: Pd = 0 is less than W
187:
188: WARNING(ORPSIM-15235): Mosfet M_M7, model N13: Ps = 0 is less than W
189:
190: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Pd = 0 is less than W
191:
192: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Ps = 0 is less than W
193:
194: WARNING(ORPSIM-15235): Mosfet M_M9, model N13: Pd = 0 is less than W
195:
196: WARNING(ORPSIM-15235): Mosfet M_M9, model N13: Ps = 0 is less than W
197:
198: WARNING(ORPSIM-15235): Mosfet M_M12, model N13: Pd = 0 is less than W
199:
200: WARNING(ORPSIM-15235): Mosfet M_M12, model N13: Ps = 0 is less than W
201:
202: WARNING(ORPSIM-15235): Mosfet M_M0, model N13: Pd = 0 is less than W
203:
204: WARNING(ORPSIM-15235): Mosfet M_M0, model N13: Ps = 0 is less than W
205:
206: WARNING(ORPSIM-15235): Mosfet M_M13, model N13: Pd = 0 is less than W
207:
208: WARNING(ORPSIM-15235): Mosfet M_M13, model N13: Ps = 0 is less than W
209:
210: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Pd = 0 is less than W
```

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211:
212: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Ps = 0 is less than W
213:
214: WARNING(ORPSIM-15235): Mosfet M_M7b, model N13: Pd = 0 is less than W
215:
216: WARNING(ORPSIM-15235): Mosfet M_M7b, model N13: Ps = 0 is less than W
217:
218: WARNING(ORPSIM-15235): Mosfet M_M9b, model N13: Pd = 0 is less than W
219:
220: WARNING(ORPSIM-15235): Mosfet M_M9b, model N13: Ps = 0 is less than W
221:
222: WARNING(ORPSIM-15235): Mosfet M_M9bc, model N13: Pd = 0 is less than W
223:
224: WARNING(ORPSIM-15235): Mosfet M_M9bc, model N13: Ps = 0 is less than W
225:
226: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Pd = 0 is less than W
227:
228: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Ps = 0 is less than W
229:
230: WARNING(ORPSIM-15236): Parameter CTA in model P13 is invalid - Ignored
231:
232: WARNING(ORPSIM-15236): Parameter CTP in model P13 is invalid - Ignored
233:
234: WARNING(ORPSIM-15236): Parameter PTA in model P13 is invalid - Ignored
235:
236: WARNING(ORPSIM-15236): Parameter PTP in model P13 is invalid - Ignored
237:
238: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Pd = 0 is less than W
239:
240: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Ps = 0 is less than W
241:
242: WARNING(ORPSIM-15235): Mosfet M_M6, model P13: Pd = 0 is less than W
243:
244: WARNING(ORPSIM-15235): Mosfet M_M6, model P13: Ps = 0 is less than W
245:
246: WARNING(ORPSIM-15235): Mosfet M_M4, model P13: Pd = 0 is less than W
247:
248: WARNING(ORPSIM-15235): Mosfet M_M4, model P13: Ps = 0 is less than W
249:
250: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Pd = 0 is less than W
251:
252: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Ps = 0 is less than W
253:
254: WARNING(ORPSIM-15235): Mosfet M_M3b, model P13: Pd = 0 is less than W
255:
256: WARNING(ORPSIM-15235): Mosfet M_M3b, model P13: Ps = 0 is less than W
257:
258: WARNING(ORPSIM-15235): Mosfet M_M5b, model P13: Pd = 0 is less than W
259:
260: WARNING(ORPSIM-15235): Mosfet M_M5b, model P13: Ps = 0 is less than W
261:
262: WARNING(ORPSIM-15235): Mosfet M_M5bc, model P13: Pd = 0 is less than W
263:
264: WARNING(ORPSIM-15235): Mosfet M_M5bc, model P13: Ps = 0 is less than W
265:
266: WARNING(ORPSIM-15235): Mosfet M_M14, model P13: Pd = 0 is less than W
267:
268: WARNING(ORPSIM-15235): Mosfet M_M14, model P13: Ps = 0 is less than W
269:
270: WARNING(ORPSIM-15235): Mosfet M_M14c, model P13: Pd = 0 is less than W
271:
272: WARNING(ORPSIM-15235): Mosfet M_M14c, model P13: Ps = 0 is less than W
273:
274: WARNING(ORPSIM-15235): Mosfet M_M15c, model P13: Pd = 0 is less than W
275:
276: WARNING(ORPSIM-15235): Mosfet M_M15c, model P13: Ps = 0 is less than W
277:
278: WARNING(ORPSIM-15235): Mosfet M_M15, model P13: Pd = 0 is less than W
279:
280: WARNING(ORPSIM-15235): Mosfet M_M15, model P13: Ps = 0 is less than W
281:
```

```
INFO(ORPSIM-15454): Model N13: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P13: Using BSIM VERSION 3.1 or lower

**** 11/27/22 22:09:45 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********

 ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
wing\opamp_folded_cascoden_wideswing\opamp_fo


 ****     MOSFET MODEL PARAMETERS


**********************************************************************************



               N13             P13
               NMOS            PMOS
  T_Measured   27              27
   T_Current   27              27
       LEVEL    7               7
           L  100.000000E-06  100.000000E-06
           W  100.000000E-06  100.000000E-06
         VTO     .332            -.3499
          KP  627.844300E-06  627.844300E-06
       GAMMA    0               0
      LAMBDA    0               0
          IS    1.000000E-15    1.000000E-15
          JS   25.000000E-09   25.000000E-09
        JSSW  400.000000E-15  400.000000E-15
          PB    1.24859         1.24859
        PBSW     .773115         .773115
          CJ    1.500000E-03    1.500000E-03
        CJSW  200.000000E-12  200.000000E-12
          MJ     .717551         .717551
        MJSW     .370699         .370699
        CGSO  275.000000E-12  275.000000E-12
        CGDO  275.000000E-12  275.000000E-12
        CGBO    0               0
         TOX    3.300000E-09    3.300000E-09
          XJ   45.000000E-09   45.000000E-09
       UCRIT   10.000000E+03   10.000000E+03
       DELTA     .0101           .0101
      DIOMOD    2               2
          K1     .36615          .4087
          K2    0               0
        LETA    0               0
        WETA    0               0
          U0     .0134           5.200000E-03
       XPART    1               1
        VTH0     .332           -.3499
          K3    0               0
          W0    0               0
         NLX  355.000000E-09  165.000000E-09
        DVT0    8.75            5
        DVT1     .7              .26
          UA   -1.800000E-09   -1.400000E-09
          UB    2.200000E-18    1.950000E-18
          UC  -30.000000E-12  -30.000000E-12
        VSAT  135.000000E+03  105.000000E+03
        RDSW  200             400
        VOFF    -.0798          -.091
     NFACTOR    1.1              .125
        CDSC    0               0
        PCLM     .1              2.5
       PDIBL1     .012            .048
       PDIBL2    7.500000E-03   50.000000E-06
        DROUT     .28             .09
       PSCBE1  866.000000E+06   10.000000E-21
```

```
352:       PSCBE2   10.000000E-21   10.000000E-21
353:           A0    2.12            2.12
354:           A1    0               0
355:           A2     .99             .4
356:        NPEAK  560.000000E+15    6.850000E+18
357:          LDD    0               0
358:         LITL   21.106870E-09   21.106870E-09
359:          KT1    -.34            -.34
360:          KT2    -.0527          -.0527
361:          UA1 -863.000000E-12 -863.000000E-12
362:          UB1    2.000000E-18    2.000000E-18
363:          UC1    0               0
364:           AT    0               0
365:         PVAG    -.28            -.06
366:         KETA     .04             .0303
367:         ETA0     .04           80
368:         ETAB    0               0
369:         KT1L    4.000000E-09    4.000000E-09
370:         DVT2     .05            -.01
371:          CIT                    2.800000E-03
372:         DSUB     .52            1.85
373:          UTE   -1.23           -1.23
374:        NGATE  500.000000E+18  500.000000E+18
375:       MOBMOD    1               1
376:      BINUNIT    2               2
377:       NQSMOD    0               0
378:          AGS    -.1              .1
379:        DVT1W    0               0
380:        DVT2W    0               0
381:         PRWG    0               0
382:      PDIBLCB    -.0135           .143251
383:         CGSL  111.550000E-12  111.550000E-12
384:         CGDL  111.550000E-12  111.550000E-12
385:       CKAPPA     .8912           .8912
386:          CLC   54.750000E-09   54.750000E-09
387:          CLE    6.46            6.46
388:         LINT   25.000000E-09   20.000000E-09
389:          LLN                    0
390:          LWN    0               0
391:         LMIN  130.000000E-09  130.000000E-09
392:         LMAX  130.000000E-09  130.000000E-09
393:          WLN    0               0
394:          WWN                    0
395:         WMIN  130.000000E-09  130.000000E-09
396:         WMAX  100.000000E-06  100.000000E-06
397:          DLC   20.000000E-09   20.000000E-09
398:          DWC    0               0
399:           CF  111.300000E-12  111.300000E-12
400:         NOIA  100.000000E+18    9.900000E+18
401:         NOIB   50.000000E+03    2.400000E+03
402:         NOIC   -1.400000E-12    1.400000E-12
403:          VTM     .025864         .025864
404:      VERSION    3.1             3.1
405:        PBSWG     .773115         .773115
406:        MJSWG     .370699         .370699
407:        CJSWG  200.000000E-12  200.000000E-12
408:        JTSCD   25.000000E-09   25.000000E-09
409:       JSTSCD  400.000000E-15  400.000000E-15
410:
411:
412: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Pd = 0 is less than W
413:
414: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Ps = 0 is less than W
415:
416: WARNING(ORPSIM-15236): Parameter CTA in model N13 is invalid - Ignored
417:
418: WARNING(ORPSIM-15236): Parameter CTP in model N13 is invalid - Ignored
419:
420: WARNING(ORPSIM-15236): Parameter PTA in model N13 is invalid - Ignored
421:
422: WARNING(ORPSIM-15236): Parameter PTP in model N13 is invalid - Ignored
```

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423:
424: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Pd = 0 is less than W
425:
426: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Ps = 0 is less than W
427:
428: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Pd = 0 is less than W
429:
430: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Ps = 0 is less than W
431:
432: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Pd = 0 is less than W
433:
434: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Ps = 0 is less than W
435:
436: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Pd = 0 is less than W
437:
438: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Ps = 0 is less than W
439:
440: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Pd = 0 is less than W
441:
442: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Ps = 0 is less than W
443:
444: WARNING(ORPSIM-15236): Parameter CTA in model P13 is invalid - Ignored
445:
446: WARNING(ORPSIM-15236): Parameter CTP in model P13 is invalid - Ignored
447:
448: WARNING(ORPSIM-15236): Parameter PTA in model P13 is invalid - Ignored
449:
450: WARNING(ORPSIM-15236): Parameter PTP in model P13 is invalid - Ignored
451:
452: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Pd = 0 is less than W
453:
454: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Ps = 0 is less than W
455:
456: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Pd = 0 is less than W
457:
458: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Ps = 0 is less than W
459: □
460: **** 11/27/22 22:09:45 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********
461:
462:  ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
     wing\opamp_folded_cascoden_wideswing\opamp_fo
463:
464:
465:  ****     SMALL SIGNAL BIAS SOLUTION       TEMPERATURE =   27.000 DEG C
466:
467:
468: ********************************************************************************
469:
470:
471:
472:  NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE
473:
474:
475: (   VO)     .63308  (  VBN)     .58551  (  VBP)     .66706  (  VD1)     .93661
476:
477: (  VD2)     .93661  (  VD9)     .25062  (  VG0)     .62662  (  VG9)     .63308
478:
479: (  VIN)     .80000  (  VIP)     .80000  ( VBNC)     .86436  ( VBPC)     .32751
480:
481: ( VD10)     .25062  ( VD14)     .92406  ( VD15)     .89385  ( VD3R)     .89009
482:
483: ( VD5B)     .89512  ( VD7R)     .24922  ( VD9B)     .24734  ( VDDA)    1.20000
484:
485: ( VICM)     .80000  ( VIDM)    0.00000  ( VSSA)    0.00000  (VCMIN)     .80000
486:
487: (VTAIL)     .19012
488:
489:
490:
491:
492:     VOLTAGE SOURCE CURRENTS
```

```
     NAME         CURRENT

     V_Vdda      -6.454E-04
     V_Vssa       6.454E-04
     V_VSdm       0.000E+00
     V_VScm       0.000E+00

     TOTAL POWER DISSIPATION   7.75E-04  WATTS


**** 11/27/22 22:09:45 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********

 ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
wing\opamp_folded_cascoden_wideswing\opamp_fo


 ****     OPERATING POINT INFORMATION      TEMPERATURE =   27.000 DEG C


**********************************************************************************




**** VOLTAGE-CONTROLLED VOLTAGE SOURCES


NAME         E_Ein       E_Eip       E_Eicm
V-SOURCE     0.000E+00   0.000E+00   8.000E-01
I-SOURCE     0.000E+00   0.000E+00   0.000E+00


**** MOSFETS


NAME         M_M1        M_M2        M_M11       M_M5        M_M3
MODEL        N13         N13         N13         P13         P13
ID           1.04E-04    1.04E-04    2.07E-04   -1.98E-04   -9.46E-05
VGS          6.10E-01    6.10E-01    6.27E-01   -5.33E-01   -6.09E-01
VDS          7.46E-01    7.46E-01    1.90E-01   -2.63E-01   -3.04E-01
VBS         -1.90E-01   -1.90E-01    0.00E+00    0.00E+00    2.63E-01
VTH          4.83E-01    4.83E-01    3.62E-01   -4.29E-01   -4.78E-01
VDSAT        1.26E-01    1.26E-01    2.20E-01   -1.14E-01   -1.34E-01
Lin0/Sat1   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
if          -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
ir          -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
TAU         -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
GM           1.43E-03    1.43E-03    1.36E-03    2.56E-03    1.08E-03
GDS          7.10E-06    7.10E-06    3.26E-04    5.47E-05    2.34E-05
GMB          2.33E-04    2.33E-04    2.27E-04    4.74E-04    1.81E-04
CBD          0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
CBS          0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
CGSOV        7.70E-15    7.70E-15    1.98E-14    4.18E-14    1.38E-14
CGDOV        7.70E-15    7.70E-15    1.98E-14    4.18E-14    1.38E-14
CGBOV        0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
 Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges
DQGDVGB      1.26E-13    1.26E-13    1.32E-12    5.71E-13    1.89E-13
DQGDVDB     -1.33E-14   -1.33E-14   -1.91E-13   -7.74E-14   -2.55E-14
DQGDVSB     -1.06E-13   -1.06E-13   -1.08E-12   -4.58E-13   -1.54E-13
DQDDVGB     -1.35E-14   -1.35E-14   -2.90E-13   -8.22E-14   -2.69E-14
DQDDVDB      1.34E-14    1.34E-14    3.60E-13    7.94E-14    2.61E-14
DQDDVSB      1.25E-16    1.25E-16   -2.62E-14    4.02E-15    1.13E-15
DQBDVGB     -1.15E-14   -1.15E-14   -9.87E-14   -5.65E-14   -1.67E-14
DQBDVDB     -8.38E-18   -8.38E-18   -6.06E-14   -7.30E-16   -2.18E-16
DQBDVSB     -1.04E-14   -1.04E-14   -1.05E-13   -4.95E-14   -1.45E-14

NAME         M_M6        M_M4        M_M8        M_M7        M_M10
MODEL        P13         P13         N13         N13         N13
ID          -1.98E-04   -9.46E-05    9.46E-05    9.46E-05    9.46E-05
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VGS	-5.33E-01	-6.09E-01	6.14E-01	6.14E-01	6.33E-01
VDS	-2.63E-01	-3.04E-01	3.82E-01	3.82E-01	2.51E-01
VBS	0.00E+00	2.63E-01	-2.51E-01	-2.51E-01	0.00E+00
VTH	-4.29E-01	-4.78E-01	5.18E-01	5.18E-01	4.74E-01
VDSAT	-1.14E-01	-1.34E-01	1.05E-01	1.05E-01	1.47E-01
Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
GM	2.56E-03	1.08E-03	1.56E-03	1.56E-03	1.10E-03
GDS	5.47E-05	2.34E-05	1.01E-05	1.01E-05	1.73E-05
GMB	4.74E-04	1.81E-04	2.45E-04	2.45E-04	1.89E-04
CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CGSOV	4.18E-14	1.38E-14	8.80E-15	8.80E-15	3.85E-15
CGDOV	4.18E-14	1.38E-14	8.80E-15	8.80E-15	3.85E-15
CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
DQGDVGB	5.71E-13	1.89E-13	1.18E-13	1.18E-13	5.39E-14
DQGDVDB	-7.74E-14	-2.55E-14	-1.59E-14	-1.59E-14	-7.50E-15
DQGDVSB	-4.58E-13	-1.54E-13	-9.56E-14	-9.56E-14	-4.36E-14
DQDDVGB	-8.22E-14	-2.69E-14	-1.64E-14	-1.64E-14	-8.35E-15
DQDDVDB	7.94E-14	2.61E-14	1.61E-14	1.61E-14	8.07E-15
DQDDVSB	4.02E-15	1.13E-15	4.05E-16	4.05E-16	5.36E-16
DQBDVGB	-5.65E-14	-1.67E-14	-1.00E-14	-1.00E-14	-4.40E-15
DQBDVDB	-7.30E-16	-2.18E-16	-3.89E-17	-3.89E-17	-1.84E-16
DQBDVSB	-4.95E-14	-1.45E-14	-9.26E-15	-9.26E-15	-4.87E-15

NAME	M_M9	M_M12	M_M0	M_M3r	M_M3b
MODEL	N13	N13	N13	P13	P13
ID	9.46E-05	4.94E-05	5.00E-05	-4.94E-05	-4.94E-05
VGS	6.33E-01	6.27E-01	6.27E-01	-8.72E-01	-5.63E-01
VDS	2.51E-01	3.28E-01	6.27E-01	-3.10E-01	-5.63E-01
VBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-01
VTH	4.74E-01	3.62E-01	3.62E-01	-3.84E-01	-4.86E-01
VDSAT	1.47E-01	2.20E-01	2.20E-01	-3.73E-01	-1.01E-01
Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
GM	1.10E-03	3.62E-04	3.69E-04	1.62E-04	7.12E-04
GDS	1.73E-05	5.07E-06	1.41E-06	5.44E-05	8.23E-06
GMB	1.89E-04	6.00E-05	6.10E-05	3.06E-05	1.18E-04
CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CGSOV	3.85E-15	4.40E-15	4.40E-15	2.12E-15	1.38E-14
CGDOV	3.85E-15	4.40E-15	4.40E-15	2.12E-15	1.38E-14
CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
DQGDVGB	5.39E-14	2.70E-13	2.66E-13	7.37E-14	1.79E-13
DQGDVDB	-7.50E-15	-1.23E-14	-8.09E-15	-1.42E-14	-2.44E-14
DQGDVSB	-4.36E-14	-2.44E-13	-2.43E-13	-5.76E-14	-1.43E-13
DQDDVGB	-8.35E-15	-1.73E-14	-8.79E-15	-1.94E-14	-2.46E-14
DQDDVDB	8.07E-15	1.69E-14	8.42E-15	2.57E-14	2.44E-14
DQDDVSB	5.36E-16	1.95E-15	5.56E-16	-3.84E-15	2.53E-16
DQBDVGB	-4.40E-15	-3.07E-14	-3.23E-14	-4.71E-15	-1.78E-14
DQBDVDB	-1.84E-16	-1.68E-15	-1.17E-16	-4.21E-15	-1.29E-17
DQBDVSB	-4.87E-15	-2.45E-14	-2.42E-14	-5.03E-15	-1.30E-14

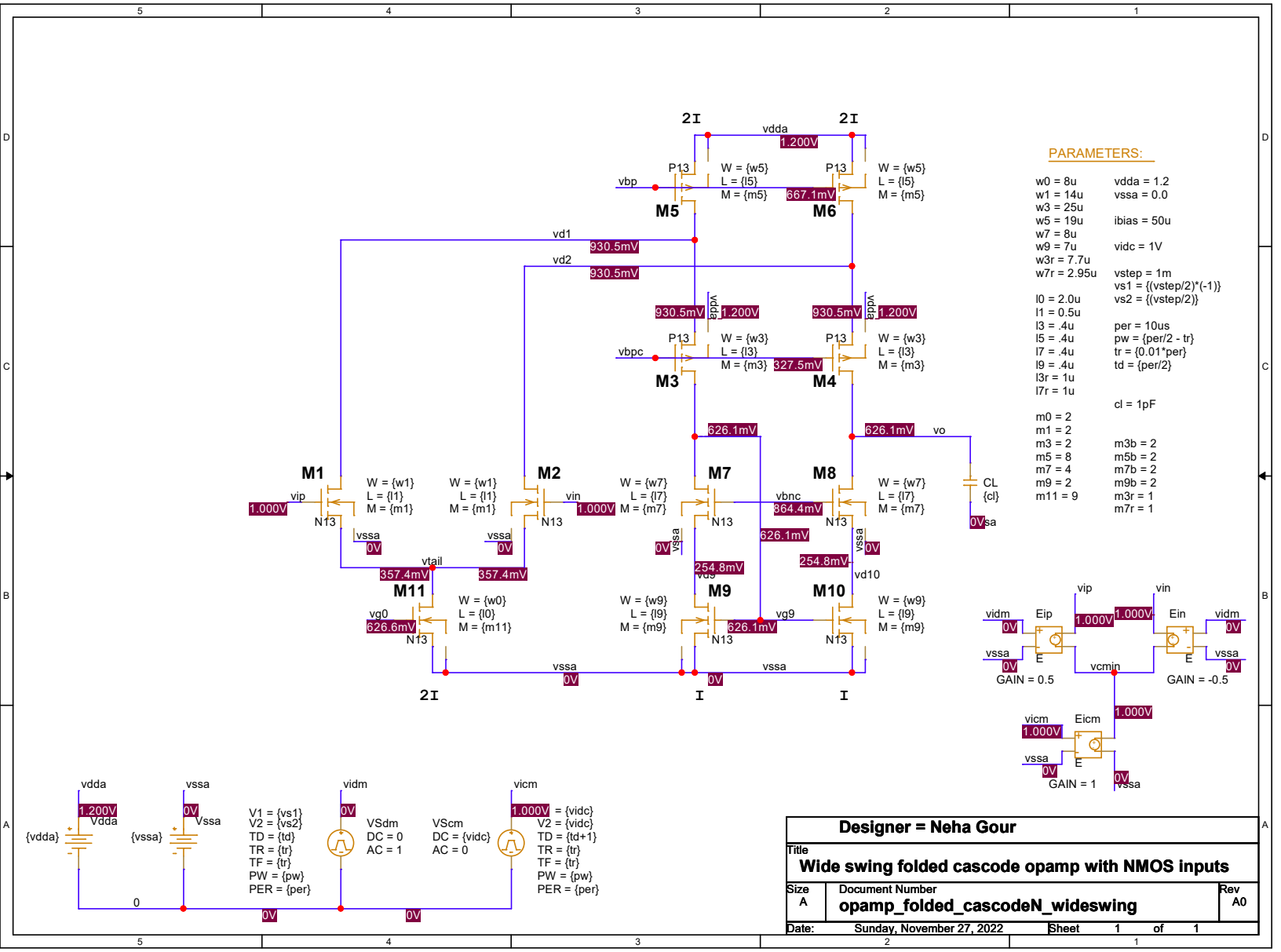
NAME	M_M13	M_M5b	M_M5bc	M_M14	M_M14c
MODEL	N13	P13	P13	P13	P13
ID	5.01E-05	-5.01E-05	-5.01E-05	-4.97E-05	-4.97E-05
VGS	6.27E-01	-5.33E-01	-5.68E-01	-5.33E-01	-5.97E-01
VDS	6.67E-01	-3.05E-01	-2.28E-01	-2.76E-01	-5.97E-02
VBS	0.00E+00	0.00E+00	3.05E-01	0.00E+00	2.76E-01
VTH	3.62E-01	-4.29E-01	-4.85E-01	-4.29E-01	-4.80E-01
VDSAT	2.20E-01	-1.14E-01	-1.05E-01	-1.14E-01	-1.25E-01
Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00

634:	GM	3.69E-04	6.48E-04	7.05E-04	6.43E-04	4.61E-04
635:	GDS	1.38E-06	1.19E-05	1.60E-05	1.30E-05	5.70E-04
636:	GMB	6.11E-05	1.20E-04	1.17E-04	1.19E-04	7.84E-05
637:	CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
638:	CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
639:	CGSOV	4.40E-15	1.05E-14	1.38E-14	1.05E-14	1.38E-14
640:	CGDOV	4.40E-15	1.05E-14	1.38E-14	1.05E-14	1.38E-14
641:	CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
642:	Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
643:	DQGDVGB	2.66E-13	1.42E-13	1.82E-13	1.43E-13	2.16E-13
644:	DQGDVDB	-7.98E-15	-1.91E-14	-2.56E-14	-1.93E-14	-6.32E-14
645:	DQGDVSB	-2.43E-13	-1.14E-13	-1.45E-13	-1.14E-13	-1.47E-13
646:	DQDDVGB	-8.57E-15	-2.00E-14	-2.74E-14	-2.03E-14	-8.33E-14
647:	DQDDVDB	8.24E-15	1.95E-14	2.63E-14	1.97E-14	1.02E-13
648:	DQDDVSB	4.83E-16	7.57E-16	1.52E-15	9.19E-16	-8.79E-15
649:	DQBDVGB	-3.23E-14	-1.42E-14	-1.73E-14	-1.41E-14	-7.26E-15
650:	DQBDVDB	-9.21E-17	-1.12E-16	-2.51E-16	-1.56E-16	-1.31E-14
651:	DQBDVSB	-2.42E-14	-1.23E-14	-1.35E-14	-1.24E-14	-1.27E-14
652:						
653:	NAME	M_M15c	M_M15	M_M7r	M_M7b	M_M9b
654:	MODEL	P13	P13	N13	N13	N13
655:	ID	-5.01E-05	-5.01E-05	4.97E-05	4.97E-05	5.01E-05
656:	VGS	-5.66E-01	-5.33E-01	8.64E-01	6.15E-01	5.86E-01
657:	VDS	-3.08E-01	-3.06E-01	2.49E-01	6.15E-01	2.47E-01
658:	VBS	3.06E-01	0.00E+00	0.00E+00	-2.49E-01	0.00E+00
659:	VTH	-4.85E-01	-4.29E-01	3.92E-01	5.18E-01	4.74E-01
660:	VDSAT	-1.04E-01	-1.14E-01	3.63E-01	1.07E-01	1.13E-01
661:	Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
662:	if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
663:	ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
664:	TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
665:	GM	7.11E-04	6.48E-04	1.57E-04	8.06E-04	7.63E-04
666:	GDS	1.16E-05	1.18E-05	9.61E-05	4.75E-06	7.73E-06
667:	GMB	1.18E-04	1.20E-04	2.70E-05	1.27E-04	1.32E-04
668:	CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
669:	CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
670:	CGSOV	1.38E-14	1.05E-14	8.11E-16	4.40E-15	3.85E-15
671:	CGDOV	1.38E-14	1.05E-14	8.11E-16	4.40E-15	3.85E-15
672:	CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
673:	Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
674:	DQGDVGB	1.81E-13	1.42E-13	2.96E-14	5.89E-14	5.29E-14
675:	DQGDVDB	-2.51E-14	-1.91E-14	-7.90E-15	-7.78E-15	-7.20E-15
676:	DQGDVSB	-1.44E-13	-1.14E-13	-2.12E-14	-4.78E-14	-4.27E-14
677:	DQDDVGB	-2.60E-14	-2.00E-14	-1.04E-14	-7.88E-15	-7.80E-15
678:	DQDDVDB	2.54E-14	1.94E-14	1.47E-14	7.82E-15	7.49E-15
679:	DQDDVSB	8.53E-16	7.51E-16	-2.90E-15	7.66E-17	4.63E-16
680:	DQBDVGB	-1.76E-14	-1.42E-14	-1.17E-15	-5.02E-15	-4.62E-15
681:	DQBDVDB	-9.27E-17	-1.11E-16	-2.40E-15	-6.27E-18	-8.99E-17
682:	DQBDVSB	-1.33E-14	-1.23E-14	-1.68E-15	-4.62E-15	-4.80E-15
683:						
684:	NAME	M_M9bc				
685:	MODEL	N13				
686:	ID	5.01E-05				
687:	VGS	6.17E-01				
688:	VDS	3.38E-01				
689:	VBS	-2.47E-01				
690:	VTH	5.18E-01				
691:	VDSAT	1.08E-01				
692:	Lin0/Sat1	-1.00E+00				
693:	if	-1.00E+00				
694:	ir	-1.00E+00				
695:	TAU	-1.00E+00				
696:	GM	8.08E-04				
697:	GDS	5.59E-06				
698:	GMB	1.27E-04				
699:	CBD	0.00E+00				
700:	CBS	0.00E+00				
701:	CGSOV	4.40E-15				
702:	CGDOV	4.40E-15				
703:	CGBOV	0.00E+00				
704:	Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					

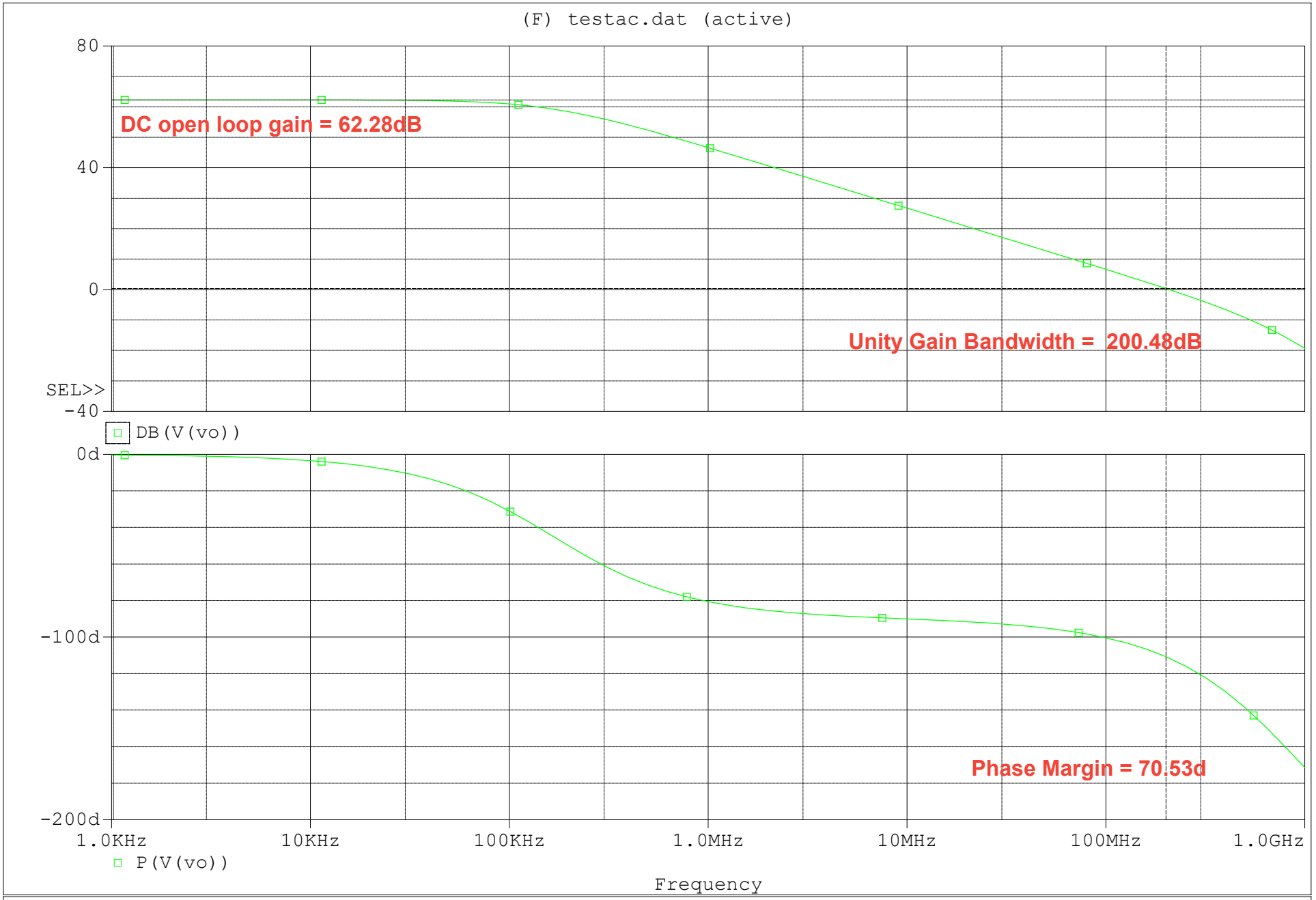
```
DQGDVGB      5.93E-14
DQGDVDB     -8.01E-15
DQGDVSB     -4.80E-14
DQDDVGB     -8.32E-15
DQDDVDB      8.12E-15
DQDDVSB      2.65E-16
DQBDVGB     -4.96E-15
DQBDVDB     -2.95E-17
DQBDVSB     -4.67E-15

          JOB CONCLUDED

**** 11/27/22 22:09:45 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********

 ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
wing\opamp_folded_cascoden_wideswing\opamp_fo


 ****     JOB STATISTICS SUMMARY


******************************************************************************



  License check-out time            =        1.05
  Total job time (using Solver 1)   =         .09
```

COMMON-MODE INPUT VOLTAGE
(V_{ICM} = 1 V)

DC Open-loop Voltage Gain,
Unity Gain Bandwidth
Phase Margin

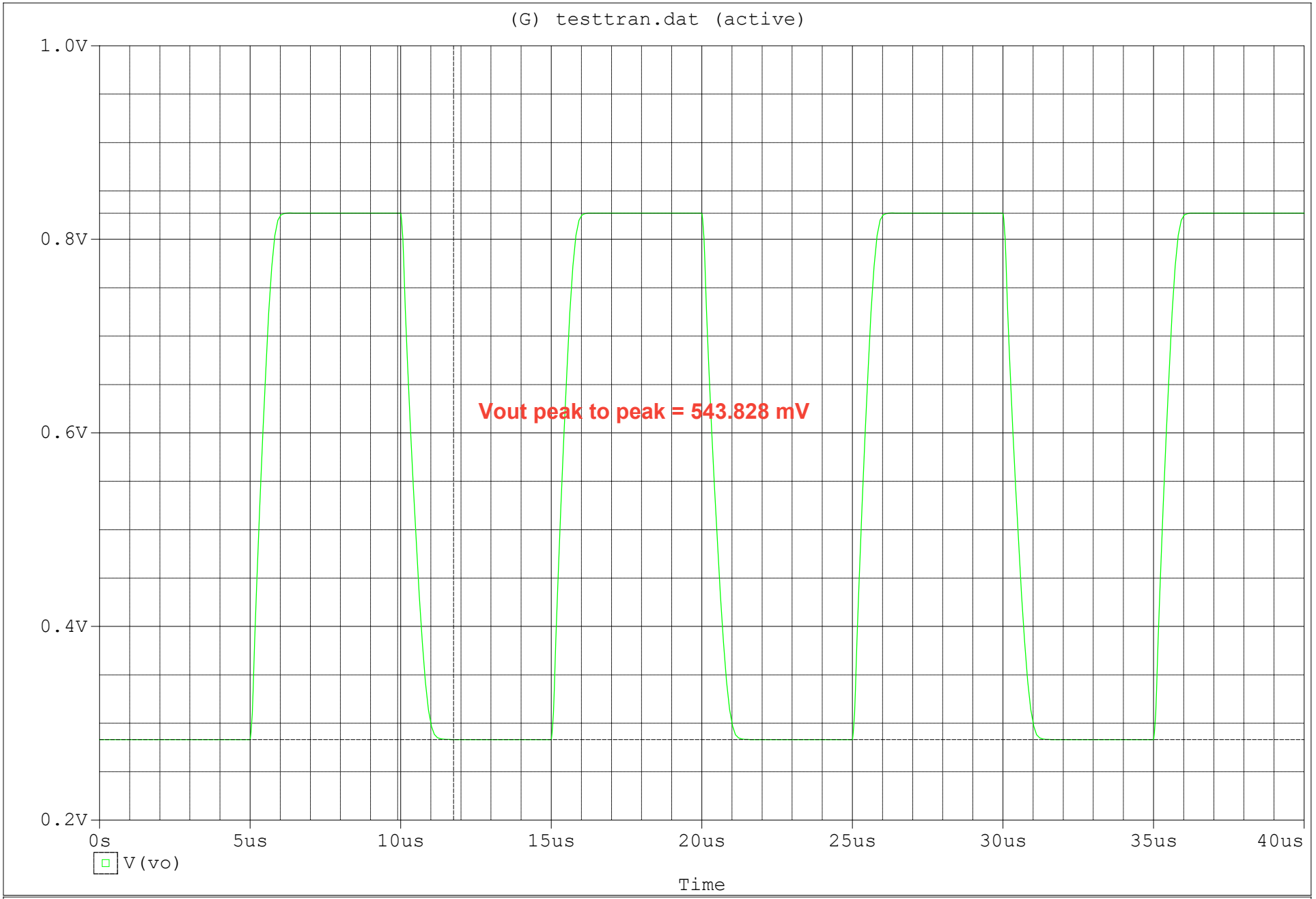

PARAMETERS:
w0 = 8u
w1 = 14u
w3 = 25u
w5 = 19u
w7 = 8u
w9 = 7u
w3r = 7.7u
w7r = 2.95u
l0 = 2.0u
l1 = 0.5u
l3 = .4u
l5 = .4u
l7 = .4u
l9 = .4u
l3r = 1u
l7r = 1u
m0 = 2
m1 = 2
m3 = 2
m5 = 8
m7 = 4
m9 = 2
m11 = 9
vdda = 1.2
vssa = 0.0
ibias = 50u
vidc = 1V
vstep = 1m
vs1 = {(vstep/2)*(-1)}
vs2 = {(vstep/2)}
per = 10us
pw = {per/2 - tr}
tr = {0.01*per}
td = {per/2}
cl = 1pF
m3b = 2
m5b = 2
m7b = 2
m9b = 2
m3r = 1
m7r = 1
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
vdda
1.200V
vssa
0V
vbp
vbpc
vip
vin
1.000V
vtail
357.4mV
vd1
930.5mV
vd2
930.5mV
667.1mV
327.5mV
626.1mV
vo
CL
{cl}
vbnc
364.4mV
254.8mV
vd10
vg0
626.6mV
vg9
626.1mV
vcmin
vidm
vicm
Eip
Ein
Eicm
GAIN = 0.5
GAIN = -0.5
GAIN = 1
2I
I
{vdda}
{vssa}
V1 = {vs1}
V2 = {vs2}
TD = {td}
TR = {tr}
TF = {tr}
PW = {pw}
PER = {per}
VSdm
DC = 0
AC = 1
VScm
DC = {vidc}
AC = 0
V2 = {vidc}
TD = {td+1}
0
Designer = Neha Gour
Title
Wide swing folded cascode opamp with NMOS inputs
Size
A
Document Number
opamp_folded_cascodeN_wideswing
Rev
A0
Date:
Sunday, November 27, 2022
Sheet
1
of
1

** Profile: "SCHEMATIC1-testac" [u:\desktop\230\project_2\opamp_folded_cascoden_wideswing\opamp_folded...
Date/Time run: 11/27/22 22:30:06 Temperature: 27.0



F1:(1.0243K,62.284) F2:(200.486M,334.849m) DIFF(F):(-200.485M,61.949)

** Profile: "SCHEMATIC1-testtran" [u:\desktop\230\project_2\opamp_folded_cascoden_wideswing\opamp_fold...
Date/Time run: 11/27/22 22:32:04 Temperature: 27.0



G1:(9.897u,827.057m) G2:(11.759u,283.228m) DIFF(G):(-1.8621u,543.828m)

```
 1: □
 2: **** 11/27/22 22:30:06 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********
 3:
 4:  ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
    wing\opamp_folded_cascoden_wideswing\opamp_fo
 5:
 6:
 7:  ****     CIRCUIT DESCRIPTION
 8:
 9:
10: ********************************************************************************
11:
12:
13:
14:
15: ** Creating circuit file "testac.cir"
16: ** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIO
    NS
17:
18: *Libraries:
19: * Profile Libraries :
20: * Local Libraries :
21: .LIB "../../../opamp_folded_cascoden_wideswing-pspicefiles/opamp_folded_cascoden_wideswi
    ng.lib"
22: * From [PSPICE NETLIST] section of U:\cdssetup\OrCAD_PSpice\17.4.0\PSpice.ini file:
23: .lib "nom.lib"
24:
25: *Analysis directives:
26: .AC DEC 10 1k 1g
27: .OP
28: .OPTIONS ADVCONV
29: .OPTIONS NUMDGT= 5
30: .OPTIONS RELTOL= 0.0001
31: .PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
32: .INC "..\SCHEMATIC1.net"
33:
34:
35:
36: **** INCLUDING SCHEMATIC1.net ****
37: * source OPAMP_FOLDED_CASCODEN_WIDESWING
38: M_M1          VD1 VIP VTAIL VSSA N13
39: + L={l1}
40: + W={w1}
41: + M={m1}
42: M_M2          VD2 VIN VTAIL VSSA N13
43: + L={l1}
44: + W={w1}
45: + M={m1}
46: M_M11          VTAIL VG0 VSSA VSSA N13
47: + L={l0}
48: + W={w0}
49: + M={m11}
50: M_M5          VD1 VBP VDDA VDDA P13
51: + L={l5}
52: + W={w5}
53: + M={m5}
54: V_Vdda          VDDA 0 {vdda}
55: V_Vssa          VSSA 0 {vssa}
56: C_CL          VSSA VO  {cl}  TC=0,0
57: M_M3          VG9 VBPC VD1 VDDA P13
58: + L={l3}
59: + W={w3}
60: + M={m3}
61: M_M6          VD2 VBP VDDA VDDA P13
62: + L={l5}
63: + W={w5}
64: + M={m5}
65: M_M4          VO VBPC VD2 VDDA P13
66: + L={l3}
67: + W={w3}
68: + M={m3}
```

```
 69: M_M8         VO VBNC VD10 VSSA N13
 70: + L={l7}
 71: + W={w7}
 72: + M={m7}
 73: M_M7         VG9 VBNC VD9 VSSA N13
 74: + L={l7}
 75: + W={w7}
 76: + M={m7}
 77: M_M10         VD10 VG9 VSSA VSSA N13
 78: + L={l9}
 79: + W={w9}
 80: + M={m9}
 81: M_M9         VD9 VG9 VSSA VSSA N13
 82: + L={l9}
 83: + W={w9}
 84: + M={m9}
 85: M_M12         VBPC VG0 VSSA VSSA N13
 86: + L={l0}
 87: + W={w0}
 88: + M={m0}
 89: I_Ibias1         VDDA VG0 DC {ibias}
 90: M_M0         VG0 VG0 VSSA VSSA N13
 91: + L={l0}
 92: + W={w0}
 93: + M={m0}
 94: M_M3r         VD3R VBPC VDDA VDDA P13
 95: + L={l3r}
 96: + W={w3r}
 97: + M={m3r}
 98: M_M3b         VBPC VBPC VD3R VDDA P13
 99: + L={l3}
100: + W={w3}
101: + M={m3b}
102: M_M13         VBP VG0 VSSA VSSA N13
103: + L={l0}
104: + W={w0}
105: + M={m0}
106: M_M5b         VD5B VBP VDDA VDDA P13
107: + L={l5}
108: + W={w5}
109: + M={m5b}
110: M_M5bc         VBP VBPC VD5B VDDA P13
111: + L={l3}
112: + W={w3}
113: + M={m3b}
114: M_M14         VD14 VBP VDDA VDDA P13
115: + L={l5}
116: + W={w5}
117: + M={m5b}
118: M_M14c         VBNC VBPC VD14 VDDA P13
119: + L={l3}
120: + W={w3}
121: + M={m3b}
122: M_M15c         VBN VBPC VD15 VDDA P13
123: + L={l3}
124: + W={w3}
125: + M={m3b}
126: M_M15         VD15 VBP VDDA VDDA P13
127: + L={l5}
128: + W={w5}
129: + M={m5b}
130: M_M7r         VD7R VBNC VSSA VSSA N13
131: + L={l7r}
132: + W={w7r}
133: + M={m7r}
134: M_M7b         VBNC VBNC VD7R VSSA N13
135: + L={l7}
136: + W={w7}
137: + M={m7b}
138: M_M9b         VD9B VBN VSSA VSSA N13
139: + L={l9}
```

```
140: + W={w9}
141: + M={m9b}
142: M_M9bc          VBN VBNC VD9B VSSA N13
143: + L={l7}
144: + W={w7}
145: + M={m7b}
146: E_Ein          VIN VCMIN VIDM VSSA -0.5
147: E_Eip          VIP VCMIN VIDM VSSA 0.5
148: E_Eicm          VCMIN VSSA VICM VSSA 1
149: V_VSdm          VIDM 0 DC 0 AC 1
150: +PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
151: V_VScm          VICM 0 DC {vidc} AC 0
152: +PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
153: .PARAM  m3r=1 l3r=1u l3=.4u m9=2 w3=25u l5=.4u cl=1pf per=10us vstep=1m w5=19u
154: +  vs1={(vstep/2)*(-1)} m7=4 l7=.4u vs2={(vstep/2)} vidc=1v w7=8u vssa=0.0 m9b=2
155: +  m7b=2 m5b=2 m5=8 m7r=1 l9=.4u ibias=50u w7r=2.95u w9=7u m3=2 tr={0.01*per}
156: +  m0=2 m1=2 vdda=1.2 td={per/2} l7r=1u m11=9 pw={per/2 - tr} w3r=7.7u l1=0.5u
157: +  w0=8u m3b=2 l0=2.0u w1=14u
158:
159: **** RESUMING testac.cir ****
160: .END
161:
162: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Pd = 0 is less than W
163:
164: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Ps = 0 is less than W
165:
166: WARNING(ORPSIM-15236): Parameter CTA in model N13 is invalid - Ignored
167:
168: WARNING(ORPSIM-15236): Parameter CTP in model N13 is invalid - Ignored
169:
170: WARNING(ORPSIM-15236): Parameter PTA in model N13 is invalid - Ignored
171:
172: WARNING(ORPSIM-15236): Parameter PTP in model N13 is invalid - Ignored
173:
174: WARNING(ORPSIM-15235): Mosfet M_M2, model N13: Pd = 0 is less than W
175:
176: WARNING(ORPSIM-15235): Mosfet M_M2, model N13: Ps = 0 is less than W
177:
178: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Pd = 0 is less than W
179:
180: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Ps = 0 is less than W
181:
182: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Pd = 0 is less than W
183:
184: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Ps = 0 is less than W
185:
186: WARNING(ORPSIM-15235): Mosfet M_M7, model N13: Pd = 0 is less than W
187:
188: WARNING(ORPSIM-15235): Mosfet M_M7, model N13: Ps = 0 is less than W
189:
190: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Pd = 0 is less than W
191:
192: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Ps = 0 is less than W
193:
194: WARNING(ORPSIM-15235): Mosfet M_M9, model N13: Pd = 0 is less than W
195:
196: WARNING(ORPSIM-15235): Mosfet M_M9, model N13: Ps = 0 is less than W
197:
198: WARNING(ORPSIM-15235): Mosfet M_M12, model N13: Pd = 0 is less than W
199:
200: WARNING(ORPSIM-15235): Mosfet M_M12, model N13: Ps = 0 is less than W
201:
202: WARNING(ORPSIM-15235): Mosfet M_M0, model N13: Pd = 0 is less than W
203:
204: WARNING(ORPSIM-15235): Mosfet M_M0, model N13: Ps = 0 is less than W
205:
206: WARNING(ORPSIM-15235): Mosfet M_M13, model N13: Pd = 0 is less than W
207:
208: WARNING(ORPSIM-15235): Mosfet M_M13, model N13: Ps = 0 is less than W
209:
210: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Pd = 0 is less than W
```

```
211:
212: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Ps = 0 is less than W
213:
214: WARNING(ORPSIM-15235): Mosfet M_M7b, model N13: Pd = 0 is less than W
215:
216: WARNING(ORPSIM-15235): Mosfet M_M7b, model N13: Ps = 0 is less than W
217:
218: WARNING(ORPSIM-15235): Mosfet M_M9b, model N13: Pd = 0 is less than W
219:
220: WARNING(ORPSIM-15235): Mosfet M_M9b, model N13: Ps = 0 is less than W
221:
222: WARNING(ORPSIM-15235): Mosfet M_M9bc, model N13: Pd = 0 is less than W
223:
224: WARNING(ORPSIM-15235): Mosfet M_M9bc, model N13: Ps = 0 is less than W
225:
226: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Pd = 0 is less than W
227:
228: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Ps = 0 is less than W
229:
230: WARNING(ORPSIM-15236): Parameter CTA in model P13 is invalid - Ignored
231:
232: WARNING(ORPSIM-15236): Parameter CTP in model P13 is invalid - Ignored
233:
234: WARNING(ORPSIM-15236): Parameter PTA in model P13 is invalid - Ignored
235:
236: WARNING(ORPSIM-15236): Parameter PTP in model P13 is invalid - Ignored
237:
238: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Pd = 0 is less than W
239:
240: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Ps = 0 is less than W
241:
242: WARNING(ORPSIM-15235): Mosfet M_M6, model P13: Pd = 0 is less than W
243:
244: WARNING(ORPSIM-15235): Mosfet M_M6, model P13: Ps = 0 is less than W
245:
246: WARNING(ORPSIM-15235): Mosfet M_M4, model P13: Pd = 0 is less than W
247:
248: WARNING(ORPSIM-15235): Mosfet M_M4, model P13: Ps = 0 is less than W
249:
250: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Pd = 0 is less than W
251:
252: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Ps = 0 is less than W
253:
254: WARNING(ORPSIM-15235): Mosfet M_M3b, model P13: Pd = 0 is less than W
255:
256: WARNING(ORPSIM-15235): Mosfet M_M3b, model P13: Ps = 0 is less than W
257:
258: WARNING(ORPSIM-15235): Mosfet M_M5b, model P13: Pd = 0 is less than W
259:
260: WARNING(ORPSIM-15235): Mosfet M_M5b, model P13: Ps = 0 is less than W
261:
262: WARNING(ORPSIM-15235): Mosfet M_M5bc, model P13: Pd = 0 is less than W
263:
264: WARNING(ORPSIM-15235): Mosfet M_M5bc, model P13: Ps = 0 is less than W
265:
266: WARNING(ORPSIM-15235): Mosfet M_M14, model P13: Pd = 0 is less than W
267:
268: WARNING(ORPSIM-15235): Mosfet M_M14, model P13: Ps = 0 is less than W
269:
270: WARNING(ORPSIM-15235): Mosfet M_M14c, model P13: Pd = 0 is less than W
271:
272: WARNING(ORPSIM-15235): Mosfet M_M14c, model P13: Ps = 0 is less than W
273:
274: WARNING(ORPSIM-15235): Mosfet M_M15c, model P13: Pd = 0 is less than W
275:
276: WARNING(ORPSIM-15235): Mosfet M_M15c, model P13: Ps = 0 is less than W
277:
278: WARNING(ORPSIM-15235): Mosfet M_M15, model P13: Pd = 0 is less than W
279:
280: WARNING(ORPSIM-15235): Mosfet M_M15, model P13: Ps = 0 is less than W
281:
```

```
INFO(ORPSIM-15454): Model N13: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P13: Using BSIM VERSION 3.1 or lower

**** 11/27/22 22:30:06 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********

 ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
wing\opamp_folded_cascoden_wideswing\opamp_fo


 ****     MOSFET MODEL PARAMETERS


**********************************************************************************



               N13             P13
               NMOS            PMOS
  T_Measured   27              27
   T_Current   27              27
       LEVEL    7               7
           L  100.000000E-06  100.000000E-06
           W  100.000000E-06  100.000000E-06
         VTO     .332            -.3499
          KP  627.844300E-06  627.844300E-06
       GAMMA    0               0
      LAMBDA    0               0
          IS    1.000000E-15    1.000000E-15
          JS   25.000000E-09   25.000000E-09
        JSSW  400.000000E-15  400.000000E-15
          PB    1.24859         1.24859
        PBSW     .773115         .773115
          CJ    1.500000E-03    1.500000E-03
        CJSW  200.000000E-12  200.000000E-12
          MJ     .717551         .717551
        MJSW     .370699         .370699
        CGSO  275.000000E-12  275.000000E-12
        CGDO  275.000000E-12  275.000000E-12
        CGBO    0               0
         TOX    3.300000E-09    3.300000E-09
          XJ   45.000000E-09   45.000000E-09
       UCRIT   10.000000E+03   10.000000E+03
       DELTA     .0101           .0101
      DIOMOD    2               2
          K1     .36615          .4087
          K2    0               0
        LETA    0               0
        WETA    0               0
          U0     .0134           5.200000E-03
       XPART    1               1
        VTH0     .332           -.3499
          K3    0               0
          W0    0               0
         NLX  355.000000E-09  165.000000E-09
        DVT0    8.75            5
        DVT1     .7              .26
          UA   -1.800000E-09   -1.400000E-09
          UB    2.200000E-18    1.950000E-18
          UC  -30.000000E-12  -30.000000E-12
        VSAT  135.000000E+03  105.000000E+03
        RDSW  200             400
        VOFF    -.0798          -.091
     NFACTOR    1.1              .125
        CDSC    0               0
        PCLM     .1              2.5
       PDIBL1     .012            .048
       PDIBL2    7.500000E-03   50.000000E-06
        DROUT     .28             .09
       PSCBE1  866.000000E+06   10.000000E-21
```

```
352:       PSCBE2   10.000000E-21   10.000000E-21
353:           A0    2.12            2.12
354:           A1    0               0
355:           A2     .99             .4
356:        NPEAK  560.000000E+15    6.850000E+18
357:          LDD    0               0
358:         LITL   21.106870E-09   21.106870E-09
359:          KT1    -.34            -.34
360:          KT2    -.0527          -.0527
361:          UA1 -863.000000E-12 -863.000000E-12
362:          UB1    2.000000E-18    2.000000E-18
363:          UC1    0               0
364:           AT    0               0
365:         PVAG    -.28            -.06
366:         KETA     .04             .0303
367:         ETA0     .04           80
368:         ETAB    0               0
369:         KT1L    4.000000E-09    4.000000E-09
370:         DVT2     .05            -.01
371:          CIT                    2.800000E-03
372:         DSUB     .52            1.85
373:          UTE   -1.23           -1.23
374:        NGATE  500.000000E+18  500.000000E+18
375:       MOBMOD    1               1
376:      BINUNIT    2               2
377:       NQSMOD    0               0
378:          AGS    -.1              .1
379:        DVT1W    0               0
380:        DVT2W    0               0
381:         PRWG    0               0
382:      PDIBLCB    -.0135           .143251
383:         CGSL  111.550000E-12  111.550000E-12
384:         CGDL  111.550000E-12  111.550000E-12
385:       CKAPPA     .8912           .8912
386:          CLC   54.750000E-09   54.750000E-09
387:          CLE    6.46            6.46
388:         LINT   25.000000E-09   20.000000E-09
389:          LLN                    0
390:          LWN    0               0
391:         LMIN  130.000000E-09  130.000000E-09
392:         LMAX  130.000000E-09  130.000000E-09
393:          WLN    0               0
394:          WWN                    0
395:         WMIN  130.000000E-09  130.000000E-09
396:         WMAX  100.000000E-06  100.000000E-06
397:          DLC   20.000000E-09   20.000000E-09
398:          DWC    0               0
399:           CF  111.300000E-12  111.300000E-12
400:         NOIA  100.000000E+18    9.900000E+18
401:         NOIB   50.000000E+03    2.400000E+03
402:         NOIC   -1.400000E-12    1.400000E-12
403:          VTM     .025864         .025864
404:      VERSION    3.1             3.1
405:        PBSWG     .773115         .773115
406:        MJSWG     .370699         .370699
407:        CJSWG  200.000000E-12  200.000000E-12
408:        JTSCD   25.000000E-09   25.000000E-09
409:       JSTSCD  400.000000E-15  400.000000E-15
410:
411:
412: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Pd = 0 is less than W
413:
414: WARNING(ORPSIM-15235): Mosfet M_M1, model N13: Ps = 0 is less than W
415:
416: WARNING(ORPSIM-15236): Parameter CTA in model N13 is invalid - Ignored
417:
418: WARNING(ORPSIM-15236): Parameter CTP in model N13 is invalid - Ignored
419:
420: WARNING(ORPSIM-15236): Parameter PTA in model N13 is invalid - Ignored
421:
422: WARNING(ORPSIM-15236): Parameter PTP in model N13 is invalid - Ignored
```

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423:
424: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Pd = 0 is less than W
425:
426: WARNING(ORPSIM-15235): Mosfet M_M11, model N13: Ps = 0 is less than W
427:
428: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Pd = 0 is less than W
429:
430: WARNING(ORPSIM-15235): Mosfet M_M8, model N13: Ps = 0 is less than W
431:
432: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Pd = 0 is less than W
433:
434: WARNING(ORPSIM-15235): Mosfet M_M10, model N13: Ps = 0 is less than W
435:
436: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Pd = 0 is less than W
437:
438: WARNING(ORPSIM-15235): Mosfet M_M7r, model N13: Ps = 0 is less than W
439:
440: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Pd = 0 is less than W
441:
442: WARNING(ORPSIM-15235): Mosfet M_M5, model P13: Ps = 0 is less than W
443:
444: WARNING(ORPSIM-15236): Parameter CTA in model P13 is invalid - Ignored
445:
446: WARNING(ORPSIM-15236): Parameter CTP in model P13 is invalid - Ignored
447:
448: WARNING(ORPSIM-15236): Parameter PTA in model P13 is invalid - Ignored
449:
450: WARNING(ORPSIM-15236): Parameter PTP in model P13 is invalid - Ignored
451:
452: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Pd = 0 is less than W
453:
454: WARNING(ORPSIM-15235): Mosfet M_M3, model P13: Ps = 0 is less than W
455:
456: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Pd = 0 is less than W
457:
458: WARNING(ORPSIM-15235): Mosfet M_M3r, model P13: Ps = 0 is less than W
459:
460: **** 11/27/22 22:30:06 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********
461:
462:  ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
     wing\opamp_folded_cascoden_wideswing\opamp_fo
463:
464:
465:  ****     SMALL SIGNAL BIAS SOLUTION       TEMPERATURE =   27.000 DEG C
466:
467:
468: ********************************************************************************
469:
470:
471:
472:  NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE
473:
474:
475: (   VO)     .62608  (  VBN)     .58551  (  VBP)     .66706  (  VD1)     .93051
476:
477: (  VD2)     .93051  (  VD9)     .25482  (  VG0)     .62662  (  VG9)     .62608
478:
479: (  VIN)    1.00000  (  VIP)    1.00000  ( VBNC)     .86436  ( VBPC)     .32751
480:
481: ( VD10)     .25482  ( VD14)     .92406  ( VD15)     .89385  ( VD3R)     .89009
482:
483: ( VD5B)     .89512  ( VD7R)     .24922  ( VD9B)     .24734  ( VDDA)    1.20000
484:
485: ( VICM)    1.00000  ( VIDM)    0.00000  ( VSSA)    0.00000  (VCMIN)    1.00000
486:
487: (VTAIL)     .35743
488:
489:
490:
491:
492:     VOLTAGE SOURCE CURRENTS
```

```
493:     NAME         CURRENT
494:
495:     V_Vdda      -6.461E-04
496:     V_Vssa       6.461E-04
497:     V_VSdm       0.000E+00
498:     V_VScm       0.000E+00
499:
500:     TOTAL POWER DISSIPATION   7.75E-04  WATTS
501:
502:
503: **** 11/27/22 22:30:06 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********
504:
505:  ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
     wing\opamp_folded_cascoden_wideswing\opamp_fo
506:
507:
508:  ****     OPERATING POINT INFORMATION      TEMPERATURE =   27.000 DEG C
509:
510:
511: ***************************************************************************
512:
513:
514:
515:
516:
517:
518: **** VOLTAGE-CONTROLLED VOLTAGE SOURCES
519:
520:
521: NAME         E_Ein       E_Eip       E_Eicm
522: V-SOURCE     0.000E+00   0.000E+00   1.000E+00
523: I-SOURCE     0.000E+00   0.000E+00   0.000E+00
524:
525:
526: **** MOSFETS
527:
528:
529: NAME         M_M1        M_M2        M_M11       M_M5        M_M3
530: MODEL        N13         N13         N13         P13         P13
531: ID           1.11E-04    1.11E-04    2.23E-04   -1.98E-04   -8.71E-05
532: VGS          6.43E-01    6.43E-01    6.27E-01   -5.33E-01   -6.03E-01
533: VDS          5.73E-01    5.73E-01    3.57E-01   -2.69E-01   -3.04E-01
534: VBS         -3.57E-01   -3.57E-01    0.00E+00    0.00E+00    2.69E-01
535: VTH          5.11E-01    5.11E-01    3.62E-01   -4.29E-01   -4.79E-01
536: VDSAT        1.31E-01    1.31E-01    2.20E-01   -1.14E-01   -1.29E-01
537: Lin0/Sat1   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
538: if          -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
539: ir          -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
540: TAU         -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00   -1.00E+00
541: GM           1.50E-03    1.50E-03    1.64E-03    2.57E-03    1.03E-03
542: GDS          7.79E-06    7.79E-06    1.60E-05    5.33E-05    2.13E-05
543: GMB          2.31E-04    2.31E-04    2.71E-04    4.75E-04    1.72E-04
544: CBD          0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
545: CBS          0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
546: CGSOV        7.70E-15    7.70E-15    1.98E-14    4.18E-14    1.38E-14
547: CGDOV        7.70E-15    7.70E-15    1.98E-14    4.18E-14    1.38E-14
548: CGBOV        0.00E+00    0.00E+00    0.00E+00    0.00E+00    0.00E+00
549:  Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges
550: DQGDVGB      1.27E-13    1.27E-13    1.21E-12    5.71E-13    1.89E-13
551: DQGDVDB     -1.38E-14   -1.38E-14   -4.91E-14   -7.72E-14   -2.54E-14
552: DQGDVSB     -1.07E-13   -1.07E-13   -1.10E-12   -4.58E-13   -1.53E-13
553: DQDDVGB     -1.40E-14   -1.40E-14   -6.61E-14   -8.18E-14   -2.67E-14
554: DQDDVDB      1.39E-14    1.39E-14    6.35E-14    7.91E-14    2.60E-14
555: DQDDVSB      2.20E-16    2.20E-16    7.88E-15    3.85E-15    1.09E-15
556: DQBDVGB     -1.10E-14   -1.10E-14   -1.40E-13   -5.65E-14   -1.68E-14
557: DQBDVDB     -1.79E-17   -1.79E-17   -5.20E-15   -6.76E-16   -1.94E-16
558: DQBDVSB     -9.53E-15   -9.53E-15   -1.10E-13   -4.95E-14   -1.44E-14
559:
560: NAME         M_M6        M_M4        M_M8        M_M7        M_M10
561: MODEL        P13         P13         N13         N13         N13
562: ID          -1.98E-04   -8.71E-05    8.71E-05    8.71E-05    8.71E-05
```

VGS	-5.33E-01	-6.03E-01	6.10E-01	6.10E-01	6.26E-01
VDS	-2.69E-01	-3.04E-01	3.71E-01	3.71E-01	2.55E-01
VBS	0.00E+00	2.69E-01	-2.55E-01	-2.55E-01	0.00E+00
VTH	-4.29E-01	-4.79E-01	5.19E-01	5.19E-01	4.74E-01
VDSAT	-1.14E-01	-1.29E-01	1.02E-01	1.02E-01	1.42E-01
Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
GM	2.57E-03	1.03E-03	1.47E-03	1.47E-03	1.06E-03
GDS	5.33E-05	2.13E-05	9.53E-06	9.53E-06	1.47E-05
GMB	4.75E-04	1.72E-04	2.32E-04	2.32E-04	1.81E-04
CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CGSOV	4.18E-14	1.38E-14	8.80E-15	8.80E-15	3.85E-15
CGDOV	4.18E-14	1.38E-14	8.80E-15	8.80E-15	3.85E-15
CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
DQGDVGB	5.71E-13	1.89E-13	1.17E-13	1.17E-13	5.37E-14
DQGDVDB	-7.72E-14	-2.54E-14	-1.59E-14	-1.59E-14	-7.41E-15
DQGDVSB	-4.58E-13	-1.53E-13	-9.49E-14	-9.49E-14	-4.36E-14
DQDDVGB	-8.18E-14	-2.67E-14	-1.64E-14	-1.64E-14	-8.18E-15
DQDDVDB	7.91E-14	2.60E-14	1.61E-14	1.61E-14	7.90E-15
DQDDVSB	3.85E-15	1.09E-15	4.19E-16	4.19E-16	5.10E-16
DQBDVGB	-5.65E-14	-1.68E-14	-1.01E-14	-1.01E-14	-4.44E-15
DQBDVDB	-6.76E-16	-1.94E-16	-3.95E-17	-3.95E-17	-1.56E-16
DQBDVSB	-4.95E-14	-1.44E-14	-9.18E-15	-9.18E-15	-4.86E-15

NAME	M_M9	M_M12	M_M0	M_M3r	M_M3b
MODEL	N13	N13	N13	P13	P13
ID	8.71E-05	4.94E-05	5.00E-05	-4.94E-05	-4.94E-05
VGS	6.26E-01	6.27E-01	6.27E-01	-8.72E-01	-5.63E-01
VDS	2.55E-01	3.28E-01	6.27E-01	-3.10E-01	-5.63E-01
VBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-01
VTH	4.74E-01	3.62E-01	3.62E-01	-3.84E-01	-4.86E-01
VDSAT	1.42E-01	2.20E-01	2.20E-01	-3.73E-01	-1.01E-01
Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
GM	1.06E-03	3.62E-04	3.69E-04	1.62E-04	7.12E-04
GDS	1.47E-05	5.07E-06	1.41E-06	5.44E-05	8.23E-06
GMB	1.81E-04	6.00E-05	6.10E-05	3.06E-05	1.18E-04
CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CGSOV	3.85E-15	4.40E-15	4.40E-15	2.12E-15	1.38E-14
CGDOV	3.85E-15	4.40E-15	4.40E-15	2.12E-15	1.38E-14
CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
DQGDVGB	5.37E-14	2.70E-13	2.66E-13	7.37E-14	1.79E-13
DQGDVDB	-7.41E-15	-1.23E-14	-8.09E-15	-1.42E-14	-2.44E-14
DQGDVSB	-4.36E-14	-2.44E-13	-2.43E-13	-5.76E-14	-1.43E-13
DQDDVGB	-8.18E-15	-1.73E-14	-8.79E-15	-1.94E-14	-2.46E-14
DQDDVDB	7.90E-15	1.69E-14	8.42E-15	2.57E-14	2.44E-14
DQDDVSB	5.10E-16	1.95E-15	5.56E-16	-3.84E-15	2.53E-16
DQBDVGB	-4.44E-15	-3.07E-14	-3.23E-14	-4.71E-15	-1.78E-14
DQBDVDB	-1.56E-16	-1.68E-15	-1.17E-16	-4.21E-15	-1.29E-17
DQBDVSB	-4.86E-15	-2.45E-14	-2.42E-14	-5.03E-15	-1.30E-14

NAME	M_M13	M_M5b	M_M5bc	M_M14	M_M14c
MODEL	N13	P13	P13	P13	P13
ID	5.01E-05	-5.01E-05	-5.01E-05	-4.97E-05	-4.97E-05
VGS	6.27E-01	-5.33E-01	-5.68E-01	-5.33E-01	-5.97E-01
VDS	6.67E-01	-3.05E-01	-2.28E-01	-2.76E-01	-5.97E-02
VBS	0.00E+00	0.00E+00	3.05E-01	0.00E+00	2.76E-01
VTH	3.62E-01	-4.29E-01	-4.85E-01	-4.29E-01	-4.80E-01
VDSAT	2.20E-01	-1.14E-01	-1.05E-01	-1.14E-01	-1.25E-01
Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00

634:	GM	3.69E-04	6.48E-04	7.05E-04	6.43E-04	4.61E-04
635:	GDS	1.38E-06	1.19E-05	1.60E-05	1.30E-05	5.70E-04
636:	GMB	6.11E-05	1.20E-04	1.17E-04	1.19E-04	7.84E-05
637:	CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
638:	CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
639:	CGSOV	4.40E-15	1.05E-14	1.38E-14	1.05E-14	1.38E-14
640:	CGDOV	4.40E-15	1.05E-14	1.38E-14	1.05E-14	1.38E-14
641:	CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
642:	Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
643:	DQGDVGB	2.66E-13	1.42E-13	1.82E-13	1.43E-13	2.16E-13
644:	DQGDVDB	-7.98E-15	-1.91E-14	-2.56E-14	-1.93E-14	-6.32E-14
645:	DQGDVSB	-2.43E-13	-1.14E-13	-1.45E-13	-1.14E-13	-1.47E-13
646:	DQDDVGB	-8.57E-15	-2.00E-14	-2.74E-14	-2.03E-14	-8.33E-14
647:	DQDDVDB	8.24E-15	1.95E-14	2.63E-14	1.97E-14	1.02E-13
648:	DQDDVSB	4.83E-16	7.57E-16	1.52E-15	9.19E-16	-8.79E-15
649:	DQBDVGB	-3.23E-14	-1.42E-14	-1.73E-14	-1.41E-14	-7.26E-15
650:	DQBDVDB	-9.21E-17	-1.12E-16	-2.51E-16	-1.56E-16	-1.31E-14
651:	DQBDVSB	-2.42E-14	-1.23E-14	-1.35E-14	-1.24E-14	-1.27E-14
652:						
653:	NAME	M_M15c	M_M15	M_M7r	M_M7b	M_M9b
654:	MODEL	P13	P13	N13	N13	N13
655:	ID	-5.01E-05	-5.01E-05	4.97E-05	4.97E-05	5.01E-05
656:	VGS	-5.66E-01	-5.33E-01	8.64E-01	6.15E-01	5.86E-01
657:	VDS	-3.08E-01	-3.06E-01	2.49E-01	6.15E-01	2.47E-01
658:	VBS	3.06E-01	0.00E+00	0.00E+00	-2.49E-01	0.00E+00
659:	VTH	-4.85E-01	-4.29E-01	3.92E-01	5.18E-01	4.74E-01
660:	VDSAT	-1.04E-01	-1.14E-01	3.63E-01	1.07E-01	1.13E-01
661:	Lin0/Sat1	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
662:	if	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
663:	ir	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
664:	TAU	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00	-1.00E+00
665:	GM	7.11E-04	6.48E-04	1.57E-04	8.06E-04	7.63E-04
666:	GDS	1.16E-05	1.18E-05	9.61E-05	4.75E-06	7.73E-06
667:	GMB	1.18E-04	1.20E-04	2.70E-05	1.27E-04	1.32E-04
668:	CBD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
669:	CBS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
670:	CGSOV	1.38E-14	1.05E-14	8.11E-16	4.40E-15	3.85E-15
671:	CGDOV	1.38E-14	1.05E-14	8.11E-16	4.40E-15	3.85E-15
672:	CGBOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
673:	Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
674:	DQGDVGB	1.81E-13	1.42E-13	2.96E-14	5.89E-14	5.29E-14
675:	DQGDVDB	-2.51E-14	-1.91E-14	-7.90E-15	-7.78E-15	-7.20E-15
676:	DQGDVSB	-1.44E-13	-1.14E-13	-2.12E-14	-4.78E-14	-4.27E-14
677:	DQDDVGB	-2.60E-14	-2.00E-14	-1.04E-14	-7.88E-15	-7.80E-15
678:	DQDDVDB	2.54E-14	1.94E-14	1.47E-14	7.82E-15	7.49E-15
679:	DQDDVSB	8.53E-16	7.51E-16	-2.90E-15	7.66E-17	4.63E-16
680:	DQBDVGB	-1.76E-14	-1.42E-14	-1.17E-15	-5.02E-15	-4.62E-15
681:	DQBDVDB	-9.27E-17	-1.11E-16	-2.40E-15	-6.27E-18	-8.99E-17
682:	DQBDVSB	-1.33E-14	-1.23E-14	-1.68E-15	-4.62E-15	-4.80E-15
683:						
684:	NAME	M_M9bc				
685:	MODEL	N13				
686:	ID	5.01E-05				
687:	VGS	6.17E-01				
688:	VDS	3.38E-01				
689:	VBS	-2.47E-01				
690:	VTH	5.18E-01				
691:	VDSAT	1.08E-01				
692:	Lin0/Sat1	-1.00E+00				
693:	if	-1.00E+00				
694:	ir	-1.00E+00				
695:	TAU	-1.00E+00				
696:	GM	8.08E-04				
697:	GDS	5.59E-06				
698:	GMB	1.27E-04				
699:	CBD	0.00E+00				
700:	CBS	0.00E+00				
701:	CGSOV	4.40E-15				
702:	CGDOV	4.40E-15				
703:	CGBOV	0.00E+00				
704:	Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					

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705: DQGDVGB      5.93E-14
706: DQGDVDB     -8.01E-15
707: DQGDVSB     -4.80E-14
708: DQDDVGB     -8.32E-15
709: DQDDVDB      8.12E-15
710: DQDDVSB      2.65E-16
711: DQBDVGB     -4.96E-15
712: DQBDVDB     -2.95E-17
713: DQBDVSB     -4.67E-15
714:
715:           JOB CONCLUDED
716:
717: **** 11/27/22 22:30:06 ******* PSpice 17.4.0 (Nov 2018) ******* ID# 0 ********
718:
719:  ** Profile: "SCHEMATIC1-testac"  [ u:\desktop\230\project_2\opamp_folded_cascoden_wides
     wing\opamp_folded_cascoden_wideswing\opamp_fo
720:
721:
722:  ****     JOB STATISTICS SUMMARY
723:
724:
725: ******************************************************************************
726:
727:
728:
729:   License check-out time            =        1.17
730:   Total job time (using Solver 1)   =         .08
731:
```

Results Summary

V_{ICM} =.8V

Sr.No.	Design Specification	Required Value	Hand Calculations	Simulation Result
1.	DC Open Loop Voltage gain	>60Db	64.08 dB	61.35 dB
2.	Unity Gain Bandwidth	>200MHz	206.81 MHz	200.486 MHz
3.	Phase Margin	70 -75 Degree	69.78 d	70.3 d
4.	Output Swing	>400$mV_{peak\text{-}to\text{-}peak}$	618.23 mV	543.01 mV

V_{ICM} = 1V

Sr.No.	Design Specification	Required Value	Hand Calculations	Simulation Result
1.	DC Open Loop Voltage gain	>60dB	65.78 dB	62.28 dB
2.	Unity Gain Bandwidth	>200MHz	205.48 MHz	200.48 MHz
3.	Phase Margin	70 -75 Degree	72.68 d	70.53 d
4.	Output Swing	>400$mV_{peak\text{-}to\text{-}peak}$	691.078 mV	543.828 mV

Conclusion

In this Project, given specifications for opamp are achieved by Folded cascode wide swing single-ended (NMOS input, PMOS cascode) topology. The design specifications are achieved by keeping all transistors in saturation (V_{ov} = 100 mV) with appropriate values of W, L, and m for each transistor. The required values for the DC open loop gain, Unity Gain Bandwidth, Phase Margin & Output Swing are achieved at a common mode input voltage of 800 Mv as well as at 1V based on AC and transient analysis.