

PROJECT – 2



EEE 230

ANALOG AND MIXED SIGNAL INTEGRATED CIRCUIT DESIGN

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SUBMISSION DATE: 12.07.2018

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AIM

I am implementing a telescopic operation amplifier using 0.35um CMOS models using SPECIFICATION 2

Required Specifications for all designs :

Process technology node = 0.35μm CMOS

Supply voltages are $V_{DD} = 3.0V$ and $V_{SS} = 0V$ (ground)

Temperature = 27° C

Minimum V_{on} for all saturated FETs = 150 mV

Phase margin between 70 and 75 degrees at unity gain

Load capacitance ≥ 2 pF

Specifications Option 2 :

Key Spec (maximize) : Unity gain bandwidth >150MHz

DC open loop voltage gain > 60 dB

V_{out} swing > 1.5 Vp-p

Common-mode input voltage range must be at least from 1.2V up to 1.8V

TYPES OF OPERATIONAL AMPLIFIER

I. Two- Stage operational amplifier:

- Lower Bandwidth but High Gain

II. Folded Cascade operational amplifier:

- Good common-mode range
- High gain
- Relatively low power-dissipation
- High output resistance

III. Telescopic operational amplifier:

- Increased Gain.
- High unity gain- bandwidth
- High input common mode voltage range

IV. Current mirror operational amplifier:

- Good Output Swing.
- High gain
- Relatively more phase margin.

TELESCOPIC OPERATIONAL AMPLIFIER

I used telescopic operational amplifier because its common-mode input voltage and the output swing is quite larger than other amplifiers. According to the specification Option-1, two stage and folded cascade was not meeting all the requirements as the gain of folded cascade op amp came out to be high but the bandwidth was not coming according to specified values. So, I eliminate two stage and folded cascade. With the current mirror, the output swing was not coming according to specified values.

I choose telescopic by meeting the specification Option-2, as the bandwidth and the gain is being satisfied. Telescopic op amps increase the gain, also with the higher bandwidth, by adding cascade devices instead of the second stage.

To increase the bandwidth, the value of input transistors and the output transistors are adjusted i.e. M1,M2, M4, also the gain is dependent on it.

To adjust the phase margin, the values of M1 AND M1c has been adjusted keeping in mind the value of I bias.

Summary of Simulation Result:

- I.** The simulation result in part 1 represents the Output Swing, Phase margin , Open loop Voltage Gain, Unit Gain Bandwidth and Transient analysis at Common-mode input voltage (V_{icm}) = 1.2V and the value of I bias is 850uA.
- II.** The simulation result in part 2 represents the Output Swing, Phase margin , Open loop Voltage Gain, Unit Gain Bandwidth and Transient analysis at Common-mode input voltage (V_{icm})= 1.8V and the value of I bias is 850uA.

TELESCOPIC OPERATIONAL AMPLIFIER

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Part – 1

(COMMON-MODE INPUT VOLTAGE ($V_{ICM}=1.2V$))

Calculations at Vicm = 1.2 V:

SR. NO.	DESIGN CHARACTERISTICS	SPECIFICATION VALUES	HAND CALCULATIONS	SIMULATED RESULTS
1.	UNITY GAIN BANDWIDTH	> 150 MHz	203.258 MHz	201.336 MHz
2.	DC OPEN LOOP VOLTAGE GAIN	> 60dB	65.21 dB	66.87dB
3.	PHASE MARGIN	70° to 75°	73.14°	71.19°
4.	OUTPUT SWING	> 1.5 Vp-p	1.83 Vp-p	1.72 Vp-p

Gain Calculations:

Telescopic Formula $A_v = g_{m1} \{ [r_{o2}c(1+g_{m2}r_{o2})] \parallel [r_{o4}c(1+g_{m4}r_{o4})] \} = 65.21 \text{ dB}$

Phase Margin Calculation:

Telescopic formula for Phase margin: $[90^\circ - \tan^{-1}(\text{unity-gain bandwidth} / f_{p1}) - \tan^{-1}(\text{unity-gain bandwidth} / f_{p2})]$ where: f_{p1} and f_{p2} is dominant pole(corner freq) and second pole frequency= 73.14°

Unit Gain Bandwidth:

Telescopic formula for unit gain Bandwidth: $BW = g_{m1} / 2\pi C_{out} = 203.258 \text{ MHz}$

Output Swing:

$$V_{o_{p-p}} = V_{dd} - 2V_{on} - V_{bn} = 1.83 \text{ V}$$

5

4

3

2

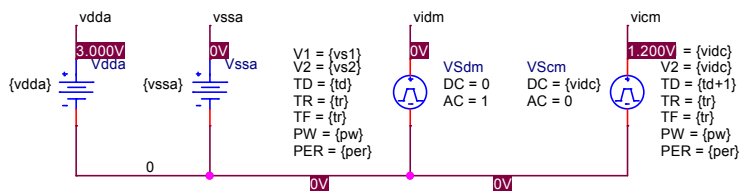
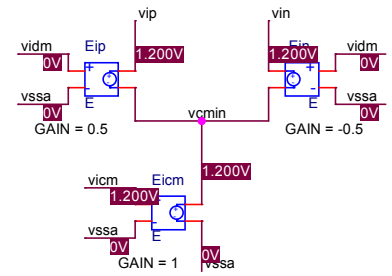
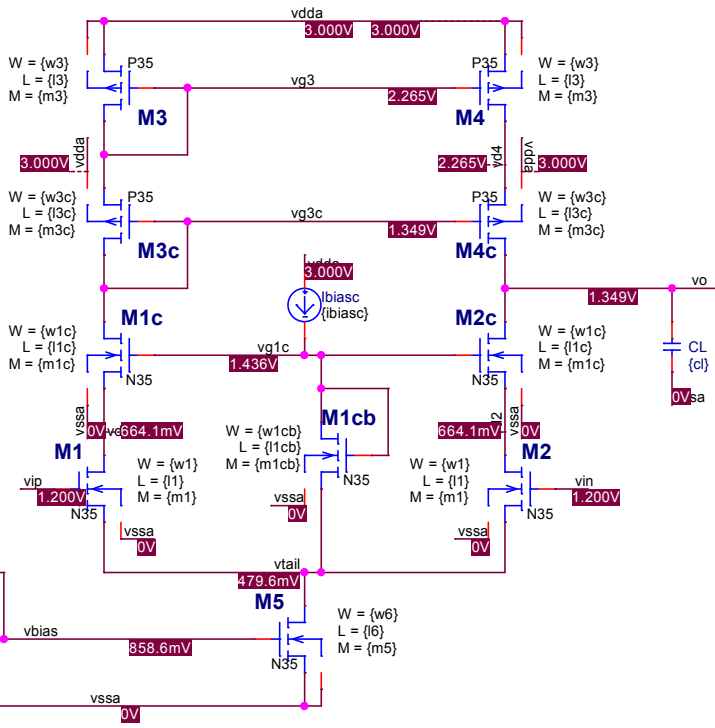
1

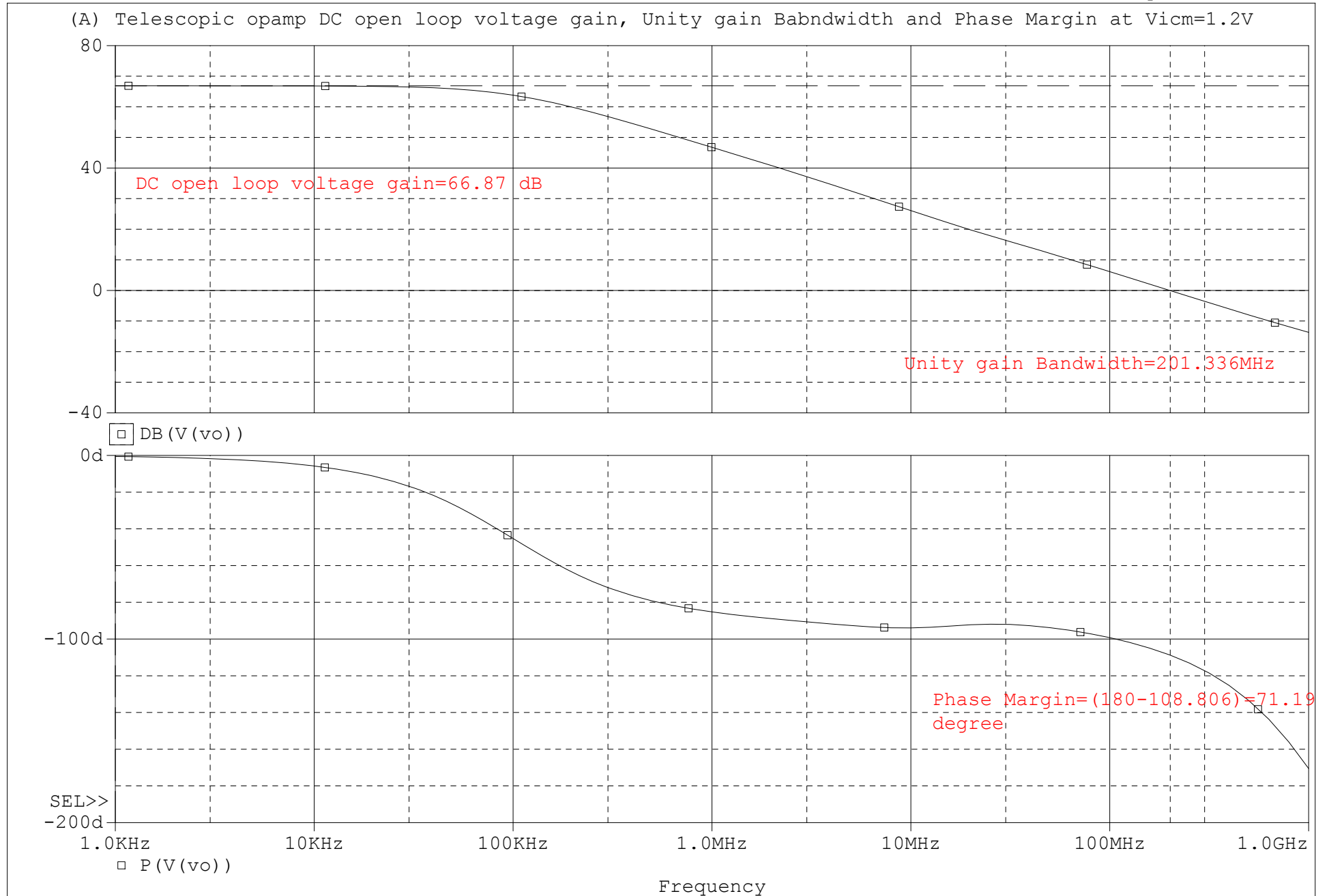
PARAMETERS:

w1 = 45u vdda = 3.0
w1c = {w1} vssa = 0.0
w1cb = 8.5u vidc = 1.2
w3 = 500u ibias = 850u
w3c = {w3} ibiasc = {ibias}
w6 = 41u

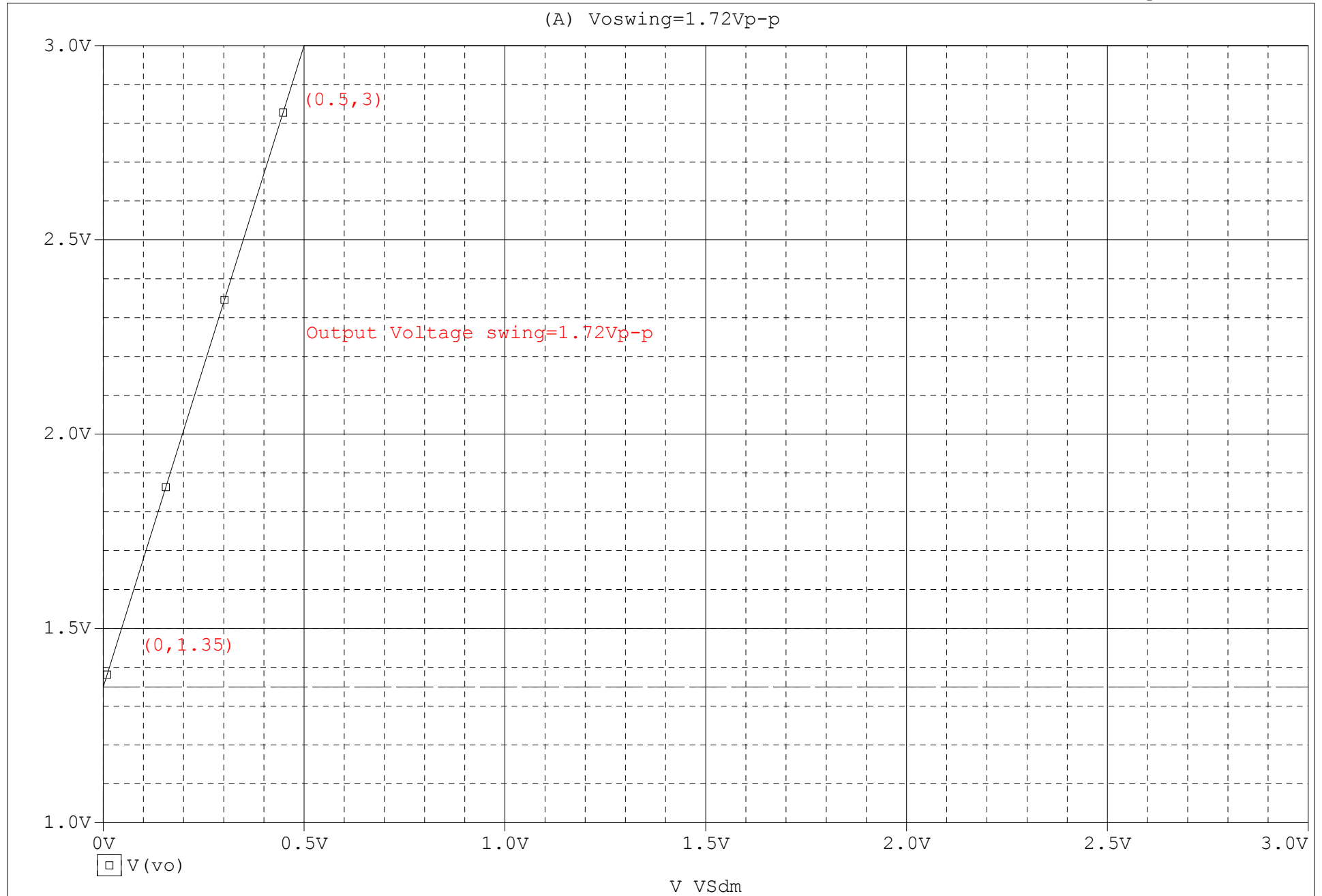
I1 = 0.52u vstep = 1m
I1c = {I1} vs1 = {(vstep/2)*(-1)}
I1cb = {I1} vs2 = {(vstep/2)}
I3 = 3u per = 10us
I3c = {I3} pw = {per/2 - tr}
I6 = 0.28u tr = {0.01*per}
td = {per/2}

m1 = 105
m1c = 70 cl = 2pF
m1cb = 10
m3 = 150
m3c = 60
m5 = 5
m6 = 0.9



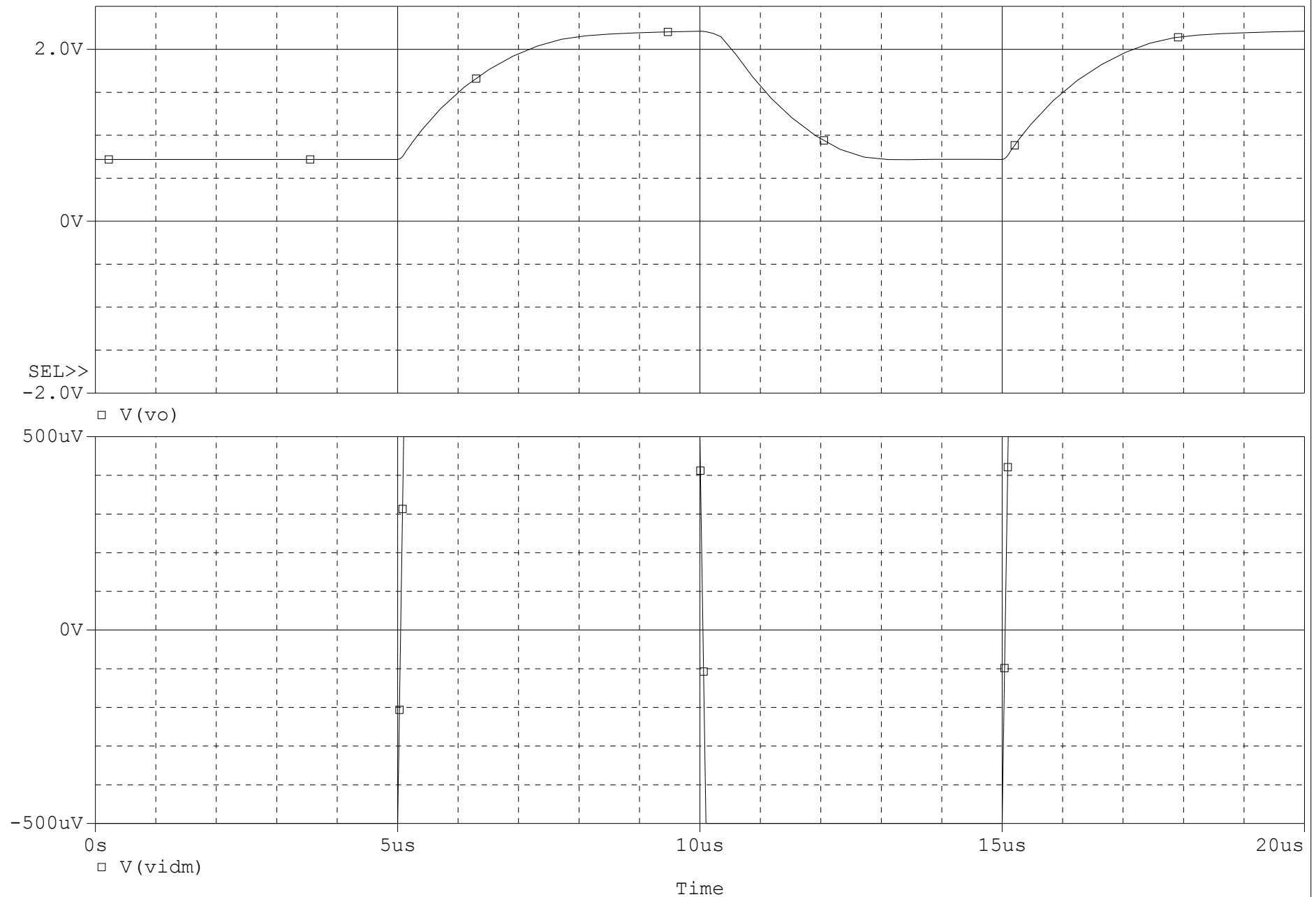


A1: (201.336M, -36.638m) A2: (1.0000K, 66.867) DIFF (A): (201.335M, -66.904)



A1: (0.000,1.3492) A2: (0.000,1.3492) DIFF(A): (0.000,0.000)

(B) testtran.dat (active)



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•
**** 11/21/18 15:45:38 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [ C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1
\testac.sim ]

****      CIRCUIT DESCRIPTION

*****

** Creating circuit file "testac.cir"
** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIONS

*Libraries:
* Profile Libraries :
* Local Libraries :
.LIB "//gaia/chakraba/models CMOS all.lib"
.LIB ".././../opamp telescopicn-pspicefiles/opamp telescopicn.lib"
* From [PSPICE NETLIST] section of C:\Users\chakraba\cdssetup\OrCAD_PSpice\17.2.0\PSpice.ini file:
.lib "nom.lib"

*Analysis directives:
.AC DEC 10 1k 1g
.OP
.OPTIONS ADVCONV
.OPTIONS NUMDGT= 5
.OPTIONS RELTOL= 0.0001
.PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
.INC "../SCHEMATIC1.net"

**** INCLUDING SCHEMATIC1.net ****
* source OPAMP TELESCOPICN
M M1          VD1 VIP VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M2          VD2 VIN VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M5          VTAIL VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
```

```

+ M={m5}
M M6          VBIAS VBIAS VSSA VSSA N35
+ L={16}
+ W={w6}
+ M={m6}
M M3          VG3 VG3 VDDA VDDA P35
+ L={13}
+ W={w3}
+ M={m3}
M M4          VD4 VG3 VDDA VDDA P35
+ L={13}
+ W={w3}
+ M={m3}
I Ibias          VDDA VBIAS DC {ibias}
V Vdda          VDDA 0 {vdda}
V Vssa          VSSA 0 {vssa}
V VSdm          VIDM 0 DC 0 AC 1
+PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
C CL          VSSA VO {cl} TC=0,0
E Eip          VIP VCMIN VIDM VSSA 0.5
E Eicm          VCMIN VSSA VICM VSSA 1
E Ein          VIN VCMIN VIDM VSSA -0.5
V VScm          VICM 0 DC {vidc} AC 0
+PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
M M3c          VG3C VG3C VG3 VDDA P35
+ L={13c}
+ W={w3c}
+ M={m3c}
M M4c          VO VG3C VD4 VDDA P35
+ L={13c}
+ W={w3c}
+ M={m3c}
M M2c          VO VG1C VD2 VSSA N35
+ L={11c}
+ W={w1c}
+ M={m1c}
M M1c          VG3C VG1C VD1 VSSA N35
+ L={11c}
+ W={w1c}
+ M={m1c}
M M1cb          VG1C VG1C VTAIL VSSA N35
+ L={11cb}
+ W={w1cb}
+ M={m1cb}
I Ibiasc          VDDA VG1C DC {ibiasc}
.PARAM l3=3u w1cb=8.5u w3=500u cl=2pf per=10us vstep=1m l3c={l3} m1c=70 m6=0.9
+ vs1={(vstep/2)*(-1)} w6=41u vs2={(vstep/2)} l6=0.28u vssa=0.0 vidc=1.2 m5=5
+ ibias=850u ibiasc={ibias} m3=150 tr={0.01*per} m1=105 vdda=3.0 td={per/2} l1c=
+ {l1} w1c={w1} w3c={w3} l1cb={l1} pw={per/2 - tr} l1=0.52u m3c=60 w1=45u m1cb=10

```

**** RESUMING testac.cir ****
.END

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Ps = 0 is less than W

INFO(ORPSIM-15454): Model N35: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P35: Using BSIM VERSION 3.1 or lower

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**** 11/21/18 15:45:38 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** MOSFET MODEL PARAMETERS

	N35	P35
	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	.500817	-.73241
KP	258.985800E-06	258.985800E-06
GAMMA	0	0
LAMBDA	0	0
RSH	3.3	2.6
IS	1.000000E-15	1.000000E-15
JS	100.000000E-06	100.000000E-06
PB	.76131	.99
PBSW	.99	.99
CJ	1.025196E-03	1.413411E-03
CJSW	304.889800E-12	413.447500E-12
MJ	.317902	.554975
MJSW	.129984	.359071
CGSO	284.000000E-12	317.000000E-12
CGDO	284.000000E-12	317.000000E-12
CGBO	1.000000E-12	1.000000E-12
TOX	8.000000E-09	8.000000E-09
XJ	100.000000E-09	100.000000E-09
UCRIT	10.000000E+03	10.000000E+03
DELTA	.01	.01
DIOMOD	2	2
K1	.560441	.437215
K2	.018158	-.015375
LETA	0	0

WETA	0	0
U0	420.4579	156.9094
XPART	.5	.5
VTH0	.500817	-.73241
K3	1.000000E-03	48.56546
W0	100.000000E-09	6.212362E-06
NLX	191.724900E-09	181.412800E-09
DVT0	3.668407	.837146
DVT1	.928603	.338643
UA	851.169300E-15	100.000000E-12
UB	1.453932E-18	2.067254E-18
UC	29.918750E-12	-15.668900E-12
VSAT	191.549500E+03	200.000000E+03
RDSW	712.8164	1.978024E+03
VOFF	-.080063	-.110788
NFACTOR	1.337384	1.671477
PCLM	1.201836	4.17521
PDIBL1	.998253	.010832
PDIBL2	6.597790E-03	2.223514E-03
DROUT	1	.067443
PSCBE1	7.195354E+09	18.801350E+09
PSCBE2	500.000000E-12	500.000000E-12
A0	1.237091	.589254
A1	0	913.214300E-06
A2	.386458	.415044
NPEAK	220.000000E+15	85.200000E+15
LDD	0	0
LITL	48.989790E-09	48.989790E-09
UA1	4.310000E-09	4.310000E-09
UB1	-7.610000E-18	-7.610000E-18
UC1	-56.000000E-12	-56.000000E-12
PVAG	.010021	5.946197
KETA	7.802194E-03	-1.017019E-03
ETA0	.180933	.023149
ETAB	4.990909E-03	.022032
K3B	.513871	-5
DVT2	-.257373	-.022621
DSUB	.441464	.63646
MOBMOD	1	1
AGS	.170423	.307773
DVT1W	0	0
DVT2W	0	0
PRWG	.125035	.01057
PRWB	-.097102	.063346
PDIBLCB	.098831	-1.000000E-03
DWG	-4.483031E-09	-17.734010E-09
DWB	11.254670E-09	13.335540E-09
B0	575.674000E-09	3.190353E-06
B1	5.000000E-06	5.000000E-06
LINT	-2.566383E-09	-38.879990E-09

WINT	87.880570E-09	85.463230E-09
WW	-1.221820E-15	-522.182000E-18
WWN	1.1907	1.215
DLC	-2.566383E-09	-38.879990E-09
DWC	87.880570E-09	85.463230E-09
CF	0	0
NOIA	100.000000E+18	9.900000E+18
NOIB	50.000000E+03	2.400000E+03
NOIC	-1.400000E-12	1.400000E-12
LKETA	-4.425361E-03	-8.660913E-03
WKETA	-916.373200E-06	543.174000E-06
PVTH0	-.022956	9.795915E-03
PRDSW	-109.7037	-123.4368
PK2	3.472875E-03	1.008100E-03
VTM	.025864	.025864
VERSION	3.1	3.1
PBSWG	.99	.99
MJSWG	.129984	.359071
CJSWG	182.000000E-12	44.200000E-12

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

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**** 11/21/18 15:45:38 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** SMALL SIGNAL BIAS SOLUTION TEMPERATURE = 27.000 DEG C

NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
(VO)	1.34916	(VD1)	.66414	(VD2)	.66414	(VD4)	2.26539
(VG3)	2.26539	(VIN)	1.20000	(VIP)	1.20000	(VDDA)	3.00000
(VG1C)	1.43644	(VG3C)	1.34916	(VICM)	1.20000	(VIDM)	0.00000
(VSSA)	0.00000	(VBIAS)	.85857	(VCMIN)	1.20000	(VTAIL)	.47958

VOLTAGE SOURCE CURRENTS
NAME CURRENT

V Vdda	-4.645E-03
V Vssa	4.645E-03
V VSdm	0.000E+00
V_VScm	0.000E+00

TOTAL POWER DISSIPATION 1.39E-02 WATTS

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**** 11/21/18 15:45:38 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

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

**** VOLTAGE-CONTROLLED VOLTAGE SOURCES

NAME	E Eip	E Eicm	E Ein
V-SOURCE	0.000E+00	1.200E+00	0.000E+00

I-SOURCE 0.000E+00 0.000E+00 0.000E+00

**** MOSFETS

NAME	M M1	M M2	M M5	M M6	M M3
MODEL	N35	N35	N35	N35	P35
ID	1.47E-03	1.47E-03	3.79E-03	8.50E-04	-1.47E-03
VGS	7.20E-01	7.20E-01	8.59E-01	8.59E-01	-7.35E-01
VDS	1.85E-01	1.85E-01	4.80E-01	8.59E-01	-7.35E-01
VBS	-4.80E-01	-4.80E-01	0.00E+00	0.00E+00	0.00E+00
VTH	7.18E-01	7.18E-01	5.98E-01	5.77E-01	-7.44E-01
VDSAT	6.31E-02	6.31E-02	1.99E-01	2.11E-01	-6.94E-02
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	3.22E-02	3.22E-02	2.47E-02	4.97E-03	3.15E-02
GDS	9.57E-04	9.57E-04	2.53E-03	4.40E-04	6.39E-05
GMB	7.89E-03	7.89E-03	6.25E-03	1.26E-03	7.01E-03
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	1.34E-12	1.34E-12	5.82E-14	1.05E-14	2.38E-11
CGDOV	1.34E-12	1.34E-12	5.82E-14	1.05E-14	2.38E-11
CGBOV	5.20E-19	5.20E-19	2.80E-19	2.80E-19	3.00E-18

Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges

DQGDVGB	8.18E-12	8.18E-12	3.24E-13	5.84E-14	4.82E-10
DQGDVDB	-1.28E-12	-1.28E-12	-4.67E-14	-8.35E-15	-2.38E-11
DQGDVSB	-5.66E-12	-5.66E-12	-2.59E-13	-4.67E-14	-3.09E-10
DQDDVGB	-3.21E-12	-3.21E-12	-1.42E-13	-2.55E-14	-1.67E-10
DQDDVDB	1.32E-12	1.32E-12	5.35E-14	9.59E-15	2.38E-11
DQDDVSB	2.36E-12	2.36E-12	1.12E-13	2.01E-14	1.77E-10
DQBDVGB	-1.76E-12	-1.76E-12	-4.04E-14	-7.32E-15	-1.48E-10
DQBDVDB	-2.76E-14	-2.76E-14	-2.45E-15	-3.98E-16	-5.50E-15
DQBDVSB	-4.03E-13	-4.03E-13	-2.17E-14	-3.85E-15	-6.86E-11

NAME	M M4	M M3c	M M4c	M M2c	M M1c
MODEL	P35	P35	P35	N35	N35
ID	-1.47E-03	-1.47E-03	-1.47E-03	1.47E-03	1.47E-03
VGS	-7.35E-01	-9.16E-01	-9.16E-01	7.72E-01	7.72E-01
VDS	-7.35E-01	-9.16E-01	-9.16E-01	6.85E-01	6.85E-01
VBS	0.00E+00	7.35E-01	7.35E-01	-6.64E-01	-6.64E-01
VTH	-7.44E-01	-8.83E-01	-8.83E-01	7.56E-01	7.56E-01
VDSAT	-6.94E-02	-9.43E-02	-9.43E-02	6.92E-02	6.92E-02
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	3.15E-02	2.78E-02	2.78E-02	3.09E-02	3.09E-02

GDS	6.39E-05	5.60E-05	5.60E-05	5.84E-04	5.84E-04
GMB	7.01E-03	4.45E-03	4.45E-03	7.07E-03	7.07E-03
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	2.38E-11	9.51E-12	9.51E-12	8.95E-13	8.95E-13
CGDOV	2.38E-11	9.51E-12	9.51E-12	8.95E-13	8.95E-13
CGBOV	3.00E-18	3.00E-18	3.00E-18	5.20E-19	5.20E-19
Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges					
DQGDVGB	4.82E-10	2.49E-10	2.49E-10	5.80E-12	5.80E-12
DQGDVDB	-2.38E-11	-9.52E-12	-9.52E-12	-8.44E-13	-8.44E-13
DQGDVSB	-3.09E-10	-2.06E-10	-2.06E-10	-4.27E-12	-4.27E-12
DQDDVGB	-1.67E-10	-1.07E-10	-1.07E-10	-2.35E-12	-2.35E-12
DQDDVDB	2.38E-11	9.51E-12	9.51E-12	8.74E-13	8.74E-13
DQDDVSB	1.77E-10	1.13E-10	1.13E-10	1.82E-12	1.82E-12
DQBDVGB	-1.48E-10	-3.51E-11	-3.51E-11	-1.10E-12	-1.10E-12
DQBDVDB	-5.50E-15	-2.29E-15	-2.29E-15	-1.27E-14	-1.27E-14
DQBDVSB	-6.86E-11	-3.02E-11	-3.02E-11	-2.70E-13	-2.70E-13

NAME	M M1cb
MODEL	N35
ID	8.50E-04
VGS	9.57E-01
VDS	9.57E-01
VBS	-4.80E-01
VTH	7.04E-01
VDSAT	2.17E-01
Lin0/Sat1	-1.00E+00
if	-1.00E+00
ir	-1.00E+00
TAU	-1.00E+00
GM	5.98E-03
GDS	1.24E-04
GMB	1.45E-03
CBD	0.00E+00
CBS	0.00E+00
CGSOV	2.41E-14
CGDOV	2.41E-14
CGBOV	5.20E-19

Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges	
DQGDVGB	1.99E-13
DQGDVDB	-2.19E-14
DQGDVSB	-1.70E-13
DQDDVGB	-8.66E-14
DQDDVDB	2.29E-14
DQDDVSB	7.94E-14
DQBDVGB	-2.60E-14
DQBDVDB	-3.15E-16
DQBDVSB	-1.27E-14

JOB CONCLUDED

•
**** 11/21/18 15:45:38 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** JOB STATISTICS SUMMARY

Total job time (using Solver 1) = .05
•

```
•
**** 11/21/18 15:47:35 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testac" [ C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1
\testac.sim ]

****      CIRCUIT DESCRIPTION

*****

** Creating circuit file "testac.cir"
** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIONS

*Libraries:
* Profile Libraries :
* Local Libraries :
.LIB "//gaia/chakraba/models CMOS all.lib"
.LIB ".././../opamp telescopicn-pspicefiles/opamp telescopicn.lib"
* From [PSPICE NETLIST] section of C:\Users\chakraba\cdssetup\OrCAD_PSpice\17.2.0\PSpice.ini file:
.lib "nom.lib"

*Analysis directives:
.DC LIN V VSdm 0 3.0 0.5
.OPTIONS ADVCONV
.OPTIONS NUMDGT= 5
.OPTIONS RELTOL= 0.0001
.PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
.INC "..\SCHEMATIC1.net"

**** INCLUDING SCHEMATIC1.net ****
* source OPAMP TELESCOPICN
M M1          VD1 VIP VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M2          VD2 VIN VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M5          VTAIL VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m5}
```

```

M M6          VBIAS VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m6}
M M3          VG3 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
M M4          VD4 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
I Ibias       VDDA VBIAS DC {ibias}
V Vdda        VDDA 0 {vdda}
V Vssa        VSSA 0 {vssa}
V VSdm        VIDM 0 DC 0 AC 1
+PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
C CL          VSSA VO {cl} TC=0,0
E Eip         VIP VCMIN VIDM VSSA 0.5
E Eicm        VCMIN VSSA VICM VSSA 1
E Ein         VIN VCMIN VIDM VSSA -0.5
V VScm        VICM 0 DC {vidc} AC 0
+PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
M M3c         VG3C VG3C VG3 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M4c         VO VG3C VD4 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M2c         VO VG1C VD2 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1c         VG3C VG1C VD1 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1cb        VG1C VG1C VTAIL VSSA N35
+ L={l1cb}
+ W={w1cb}
+ M={m1cb}
I Ibiasc      VDDA VG1C DC {ibiasc}
.PARAM l3=3u w1cb=8.5u w3=500u cl=2pf per=10us vstep=1m l3c={l3} m1c=70 m6=0.9
+ vs1={ (vstep/2)*(-1) } w6=41u vs2={ (vstep/2) } l6=0.28u vssa=0.0 vidc=1.2 m5=5
+ ibias=850u ibiasc={ibias} m3=150 tr={0.01*per} m1=105 vdda=3.0 td={per/2} l1c=
+ {l1} w1c={w1} w3c={w3} l1cb={l1} pw={per/2 - tr} l1=0.52u m3c=60 w1=45u m1cb=10

```

**** RESUMING testac.cir ****

.END

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Ps = 0 is less than W

INFO(ORPSIM-15454): Model N35: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P35: Using BSIM VERSION 3.1 or lower

•
**** 11/21/18 15:47:35 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** MOSFET MODEL PARAMETERS

	N35	P35
	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	.500817	-.73241
KP	258.985800E-06	258.985800E-06
GAMMA	0	0
LAMBDA	0	0
RSH	3.3	2.6
IS	1.000000E-15	1.000000E-15
JS	100.000000E-06	100.000000E-06
PB	.76131	.99
PBSW	.99	.99
CJ	1.025196E-03	1.413411E-03
CJSW	304.889800E-12	413.447500E-12
MJ	.317902	.554975
MJSW	.129984	.359071
CGSO	284.000000E-12	317.000000E-12
CGDO	284.000000E-12	317.000000E-12
CGBO	1.000000E-12	1.000000E-12
TOX	8.000000E-09	8.000000E-09
XJ	100.000000E-09	100.000000E-09
UCRIT	10.000000E+03	10.000000E+03
DELTA	.01	.01
DIOMOD	2	2
K1	.560441	.437215
K2	.018158	-.015375
LETA	0	0
WETA	0	0

U0	420.4579	156.9094
XPART	.5	.5
VTH0	.500817	-.73241
K3	1.000000E-03	48.56546
W0	100.000000E-09	6.212362E-06
NLX	191.724900E-09	181.412800E-09
DVT0	3.668407	.837146
DVT1	.928603	.338643
UA	851.169300E-15	100.000000E-12
UB	1.453932E-18	2.067254E-18
UC	29.918750E-12	-15.668900E-12
VSAT	191.549500E+03	200.000000E+03
RDSW	712.8164	1.978024E+03
VOFF	-.080063	-.110788
NFACTOR	1.337384	1.671477
PCLM	1.201836	4.17521
PDIBL1	.998253	.010832
PDIBL2	6.597790E-03	2.223514E-03
DROUT	1	.067443
PSCBE1	7.195354E+09	18.801350E+09
PSCBE2	500.000000E-12	500.000000E-12
A0	1.237091	.589254
A1	0	913.214300E-06
A2	.386458	.415044
NPEAK	220.000000E+15	85.200000E+15
LDD	0	0
LITL	48.989790E-09	48.989790E-09
UA1	4.310000E-09	4.310000E-09
UB1	-7.610000E-18	-7.610000E-18
UC1	-56.000000E-12	-56.000000E-12
PVAG	.010021	5.946197
KETA	7.802194E-03	-1.017019E-03
ETA0	.180933	.023149
ETAB	4.990909E-03	.022032
K3B	.513871	-5
DVT2	-.257373	-.022621
DSUB	.441464	.63646
MOBMOD	1	1
AGS	.170423	.307773
DVT1W	0	0
DVT2W	0	0
PRWG	.125035	.01057
PRWB	-.097102	.063346
PDIBLCB	.098831	-1.000000E-03
DWG	-4.483031E-09	-17.734010E-09
DWB	11.254670E-09	13.335540E-09
B0	575.674000E-09	3.190353E-06
B1	5.000000E-06	5.000000E-06
LINT	-2.566383E-09	-38.879990E-09
WINT	87.880570E-09	85.463230E-09

WW	-1.221820E-15	-522.182000E-18
WWN	1.1907	1.215
DLC	-2.566383E-09	-38.879990E-09
DWC	87.880570E-09	85.463230E-09
CF	0	0
NOIA	100.000000E+18	9.900000E+18
NOIB	50.000000E+03	2.400000E+03
NOIC	-1.400000E-12	1.400000E-12
LKETA	-4.425361E-03	-8.660913E-03
WKETA	-916.373200E-06	543.174000E-06
PVTH0	-.022956	9.795915E-03
PRDSW	-109.7037	-123.4368
PK2	3.472875E-03	1.008100E-03
VTM	.025864	.025864
VERSION	3.1	3.1
PBSWG	.99	.99
MJSWG	.129984	.359071
CJSWG	182.000000E-12	44.200000E-12

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-PSpiceFiles\SCHEMATIC1\testac\testac.out.1

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

JOB CONCLUDED

•

**** 11/21/18 15:47:35 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** JOB STATISTICS SUMMARY

• Total job time (using Solver 1) = .05

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•
**** 11/21/18 15:48:53 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testtran" [ C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schemati
c1\testtran.s

****      CIRCUIT DESCRIPTION

*****

** Creating circuit file "testtran.cir"
** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIONS

*Libraries:
* Profile Libraries :
* Local Libraries :
.LIB "//gaia/chakraba/models CMOS all.lib"
.LIB ".././../opamp telescopicn-pspicefiles/opamp telescopicn.lib"
* From [PSPICE NETLIST] section of C:\Users\chakraba\cdssetup\OrCAD_PSpice\17.2.0\PSpice.ini file:
.lib "nom.lib"

*Analysis directives:
.TRAN 0 20us 0 10us
.OPTIONS ADVCONV
.PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
.INC "../SCHEMATIC1.net"

**** INCLUDING SCHEMATIC1.net ****
* source OPAMP TELESCOPICN
M M1          VD1 VIP VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M2          VD2 VIN VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M5          VTAIL VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m5}
M M6          VBIAS VBIAS VSSA VSSA N35
+ L={l6}
```

```

+ W={w6}
+ M={m6}
M M3          VG3 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
M M4          VD4 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
I Ibias       VDDA VBIAS DC {ibias}
V Vdda        VDDA 0 {vdda}
V Vssa        VSSA 0 {vssa}
V VSdm        VIDM 0 DC 0 AC 1
+PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
C CL          VSSA VO {cl} TC=0,0
E Eip         VIP VCMIN VIDM VSSA 0.5
E Eicm        VCMIN VSSA VICM VSSA 1
E Ein         VIN VCMIN VIDM VSSA -0.5
V VScm        VICM 0 DC {vidc} AC 0
+PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
M M3c         VG3C VG3C VG3 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M4c         VO VG3C VD4 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M2c         VO VG1C VD2 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1c         VG3C VG1C VD1 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1cb        VG1C VG1C VTAIL VSSA N35
+ L={l1cb}
+ W={w1cb}
+ M={m1cb}
I Ibiasc      VDDA VG1C DC {ibiase}
.PARAM l3=3u w1cb=8.5u w3=500u cl=2pf per=10us vstep=1m l3c={l3} m1c=70 m6=0.9
+ vs1={ (vstep/2)*(-1) } w6=41u vs2={ (vstep/2) } l6=0.28u vssa=0.0 vidc=1.2 m5=5
+ ibias=850u ibiase={ibias} m3=150 tr={0.01*per} m1=105 vdda=3.0 td={per/2} l1c=
+ {l1} w1c={w1} w3c={w3} l1cb={l1} pw={per/2 - tr} l1=0.52u m3c=60 w1=45u m1cb=10

**** RESUMING testtran.cir ****
.END

```

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Ps = 0 is less than W
INFO(ORPSIM-15454): Model N35: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P35: Using BSIM VERSION 3.1 or lower

•
**** 11/21/18 15:48:53 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testtran" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testtran.s

**** MOSFET MODEL PARAMETERS

	N35	P35
	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	.500817	-.73241
KP	258.985800E-06	258.985800E-06
GAMMA	0	0
LAMBDA	0	0
RSH	3.3	2.6
IS	1.000000E-15	1.000000E-15
JS	100.000000E-06	100.000000E-06
PB	.76131	.99
PBSW	.99	.99
CJ	1.025196E-03	1.413411E-03
CJSW	304.889800E-12	413.447500E-12
MJ	.317902	.554975
MJSW	.129984	.359071
CGSO	284.000000E-12	317.000000E-12
CGDO	284.000000E-12	317.000000E-12
CGBO	1.000000E-12	1.000000E-12
TOX	8.000000E-09	8.000000E-09
XJ	100.000000E-09	100.000000E-09
UCRIT	10.000000E+03	10.000000E+03
DELTA	.01	.01
DIOMOD	2	2
K1	.560441	.437215
K2	.018158	-.015375
LETA	0	0
WETA	0	0
U0	420.4579	156.9094
XPART	.5	.5

VTH0	.500817	-.73241
K3	1.000000E-03	48.56546
W0	100.000000E-09	6.212362E-06
NLX	191.724900E-09	181.412800E-09
DVT0	3.668407	.837146
DVT1	.928603	.338643
UA	851.169300E-15	100.000000E-12
UB	1.453932E-18	2.067254E-18
UC	29.918750E-12	-15.668900E-12
VSAT	191.549500E+03	200.000000E+03
RDSW	712.8164	1.978024E+03
VOFF	-.080063	-.110788
NFACTOR	1.337384	1.671477
PCLM	1.201836	4.17521
PDIBL1	.998253	.010832
PDIBL2	6.597790E-03	2.223514E-03
DROUT	1	.067443
PSCBE1	7.195354E+09	18.801350E+09
PSCBE2	500.000000E-12	500.000000E-12
A0	1.237091	.589254
A1	0	913.214300E-06
A2	.386458	.415044
NPEAK	220.000000E+15	85.200000E+15
LDD	0	0
LITL	48.989790E-09	48.989790E-09
UA1	4.310000E-09	4.310000E-09
UB1	-7.610000E-18	-7.610000E-18
UC1	-56.000000E-12	-56.000000E-12
PVAG	.010021	5.946197
KETA	7.802194E-03	-1.017019E-03
ETA0	.180933	.023149
ETAB	4.990909E-03	.022032
K3B	.513871	-5
DVT2	-.257373	-.022621
DSUB	.441464	.63646
MOBMOD	1	1
AGS	.170423	.307773
DVT1W	0	0
DVT2W	0	0
PRWG	.125035	.01057
PRWB	-.097102	.063346
PDIBLCB	.098831	-1.000000E-03
DWG	-4.483031E-09	-17.734010E-09
DWB	11.254670E-09	13.335540E-09
B0	575.674000E-09	3.190353E-06
B1	5.000000E-06	5.000000E-06
LINT	-2.566383E-09	-38.879990E-09
WINT	87.880570E-09	85.463230E-09
WW	-1.221820E-15	-522.182000E-18
WWN	1.1907	1.215

DLC	-2.566383E-09	-38.879990E-09
DWC	87.880570E-09	85.463230E-09
CF	0	0
NOIA	100.000000E+18	9.900000E+18
NOIB	50.000000E+03	2.400000E+03
NOIC	-1.400000E-12	1.400000E-12
LKETA	-4.425361E-03	-8.660913E-03
WKETA	-916.373200E-06	543.174000E-06
PVTH0	-.022956	9.795915E-03
PRDSW	-109.7037	-123.4368
PK2	3.472875E-03	1.008100E-03
VTM	.025864	.025864
VERSION	3.1	3.1
PBSWG	.99	.99
MJSWG	.129984	.359071
CJSWG	182.000000E-12	44.200000E-12

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

•

**** 11/21/18 15:48:53 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testtran" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testtran.s

**** INITIAL TRANSIENT SOLUTION TEMPERATURE = 27.000 DEG C

NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
(VO)	.7188	(VD1)	.6640	(VD2)	.6479	(VD4)	2.2644
(VG3)	2.2654	(VIN)	1.2003	(VIP)	1.1998	(VDDA)	3.0000
(VG1C)	1.4362	(VG3C)	1.3492	(VICM)	1.2000	(VIDM)	-500.0E-06
(VSSA)	0.0000	(VBIAS)	.8586	(VCMIN)	1.2000	(VTAIL)	.4794

VOLTAGE SOURCE CURRENTS
NAME CURRENT

V Vdda	-4.644E-03
V Vssa	4.644E-03
V VSdm	0.000E+00
V_VScm	0.000E+00

TOTAL POWER DISSIPATION 1.39E-02 WATTS

JOB CONCLUDED

**** 11/21/18 15:48:53 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testtran" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testtran.s

**** JOB STATISTICS SUMMARY

Total job time (using Solver 1) = .06

Part – 2

**(COMMON-MODE INPUT VOLTAGE
(VICM=1.8V))**

Calculations at Vicm = 1.8 V:

SR. NO.	DESIGN CHARACTERISTICS	SPECIFICATION VALUES	HAND CALCULATIONS	SIMULATED RESULTS
1.	UNITY GAIN BANDWIDTH	> 150 MHz	257.57 MHz	255.190MHz
2.	DC OPEN LOOP VOLTAGE GAIN	> 60dB	61.190	60.79 dB
3.	PHASE MARGIN	70° to 75°	71.16°	70.36°
4.	OUTPUT SWING	> 1.5Vp-p	1.74V	1.76 Vp-p

Gain Calculations:

Telescopic Formula $A_v = g_{m1} \{ [r_{o2}(1+g_{m2}r_{o2})] \parallel [r_{o4}(1+g_{m4}r_{o4})] \}$
 $= 61.190 \text{ dB}$

Phase Margin Calculation:

Telescopic formula for Phase margin: $[90^\circ - \tan^{-1}(\text{unity-gain bandwidth} / f_{p1}) - \tan^{-1}(\text{unity-gain bandwidth} / f_{p2})]$, where: f_{p1} and f_{p2} is dominant pole(corner freq) and second pole frequency = 71.16°

Unit Gain Bandwidth:

Telescopic formula for unit gain Bandwidth: $BW = g_{m1} / 2\pi C_{out} = 257.57 \text{ MHz}$

Output Swing:

$$V_{O_{p-p}} = 1.74V = (V_{dd} - 2V_{on} - V_{bn})V_{O_{p-p}}$$

5

4

3

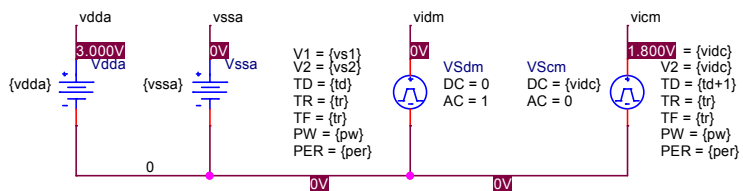
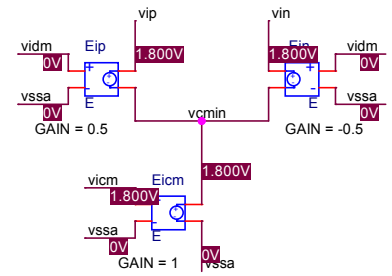
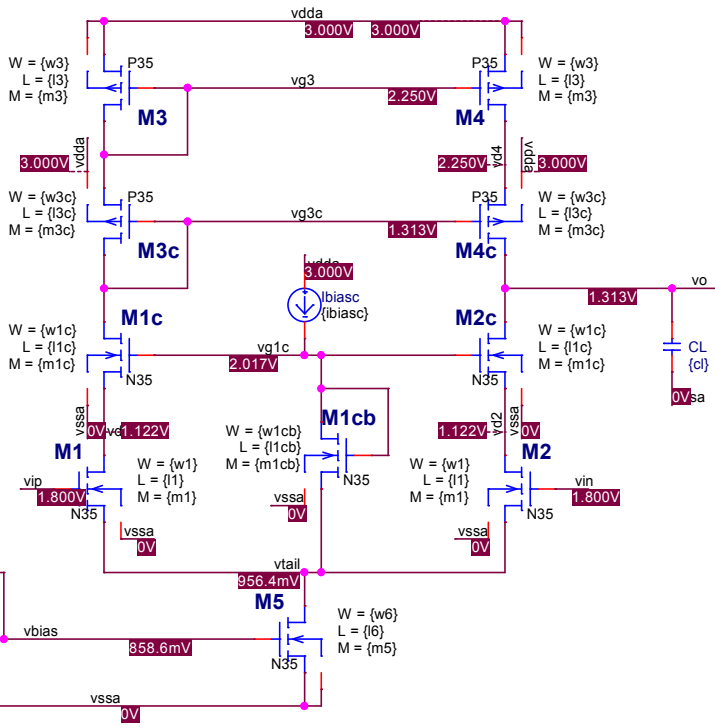
2

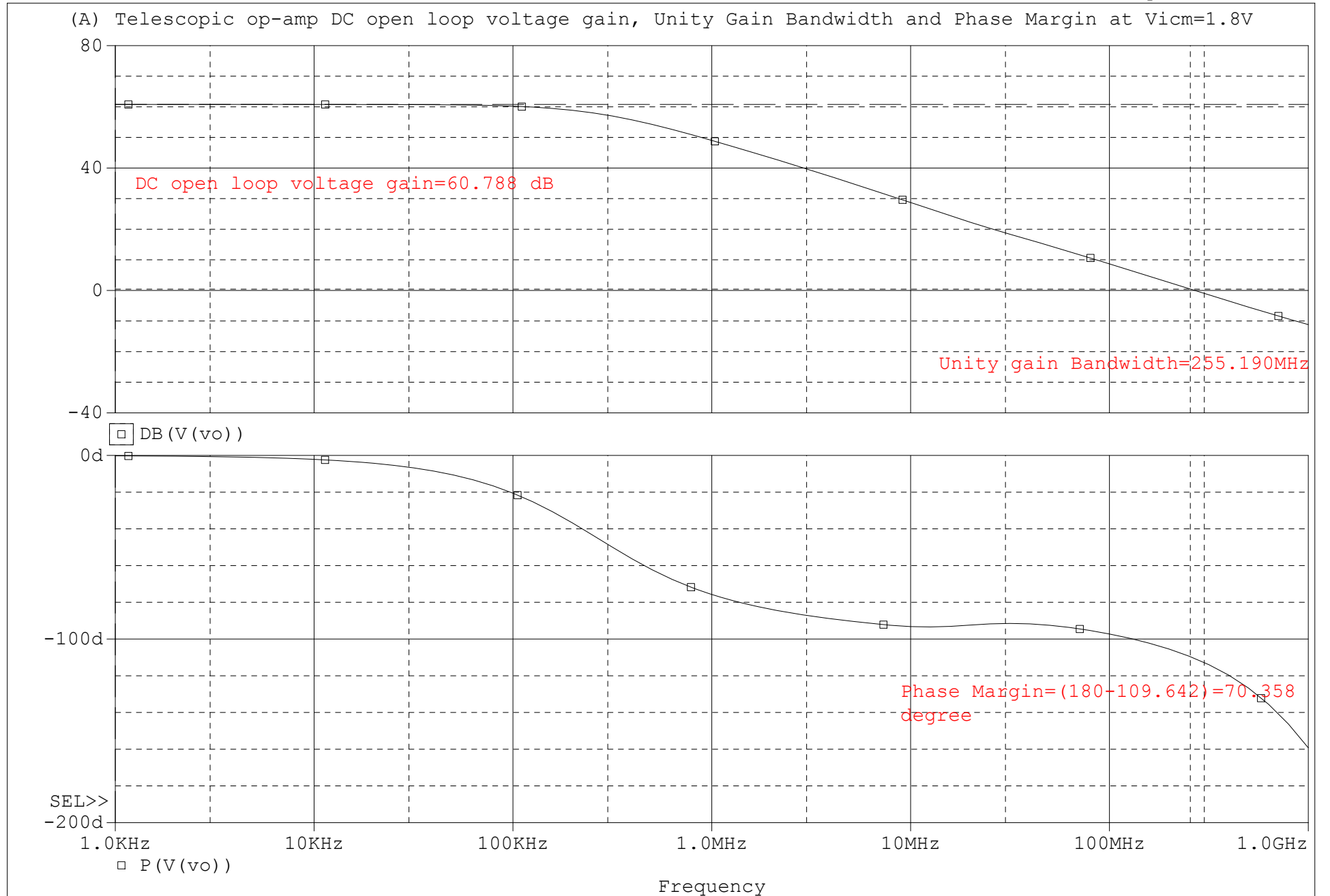
1

PARAMETERS:

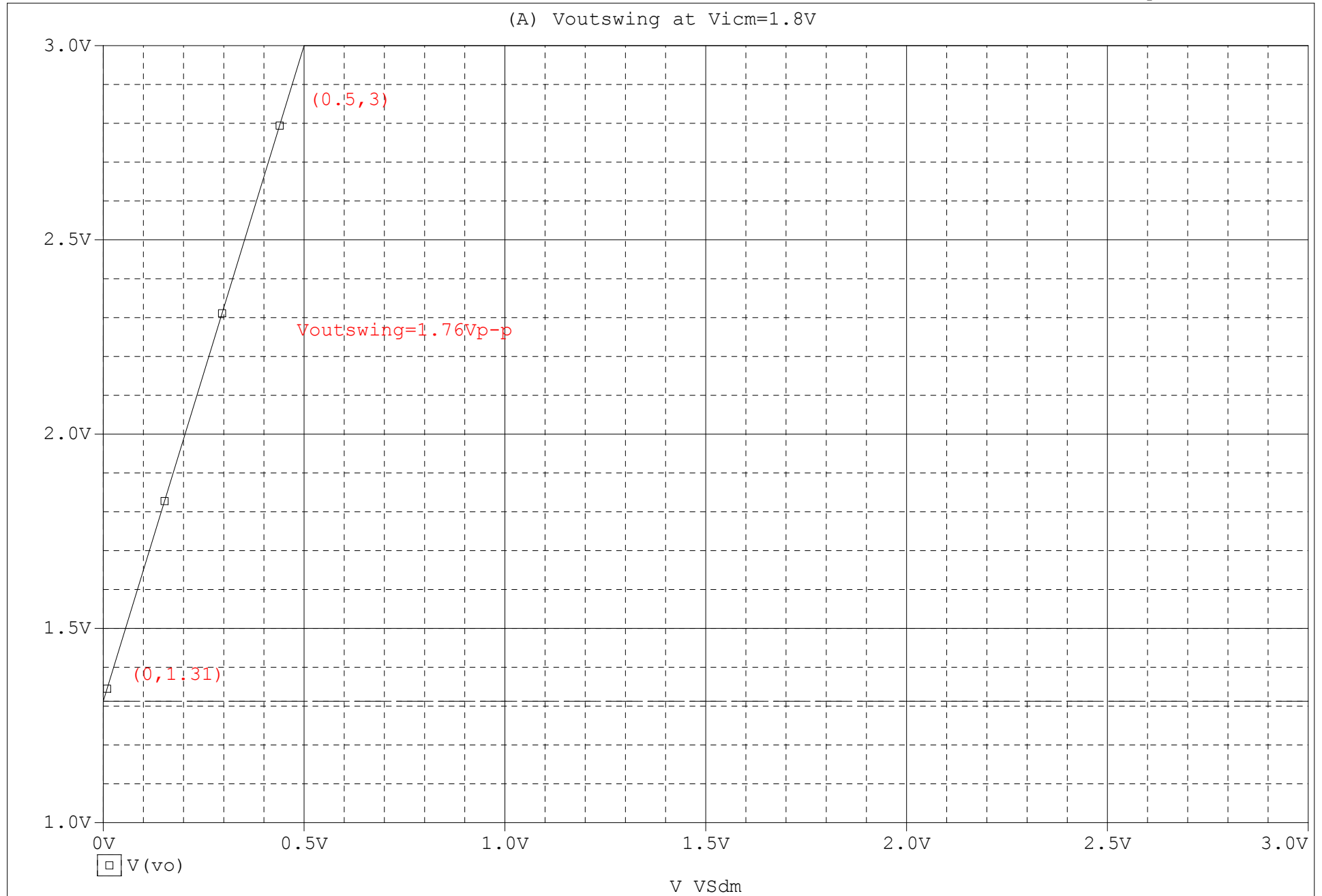
w1 = 45u
w1c = {w1}
w1cb = 8.5u
w3 = 500u
w3c = {w3}
w6 = 41u
vdda = 3.0
vssa = 0.0
vidc = 1.8
ibias = 850u
ibiasc = {ibias}

I1 = 0.52u
I1c = {I1}
I1cb = {I1}
I3 = 3u
I3c = {I3}
I6 = 0.28u
m1 = 105
m1c = 70
m1cb = 10
m3 = 150
m3c = 60
m5 = 5
m6 = 0.9
vstep = 1m
vs1 = {(vstep/2)*(-1)}
vs2 = {(vstep/2)}
per = 10us
pw = {per/2 - tr}
tr = {0.01*per}
td = {per/2}
cl = 2pF

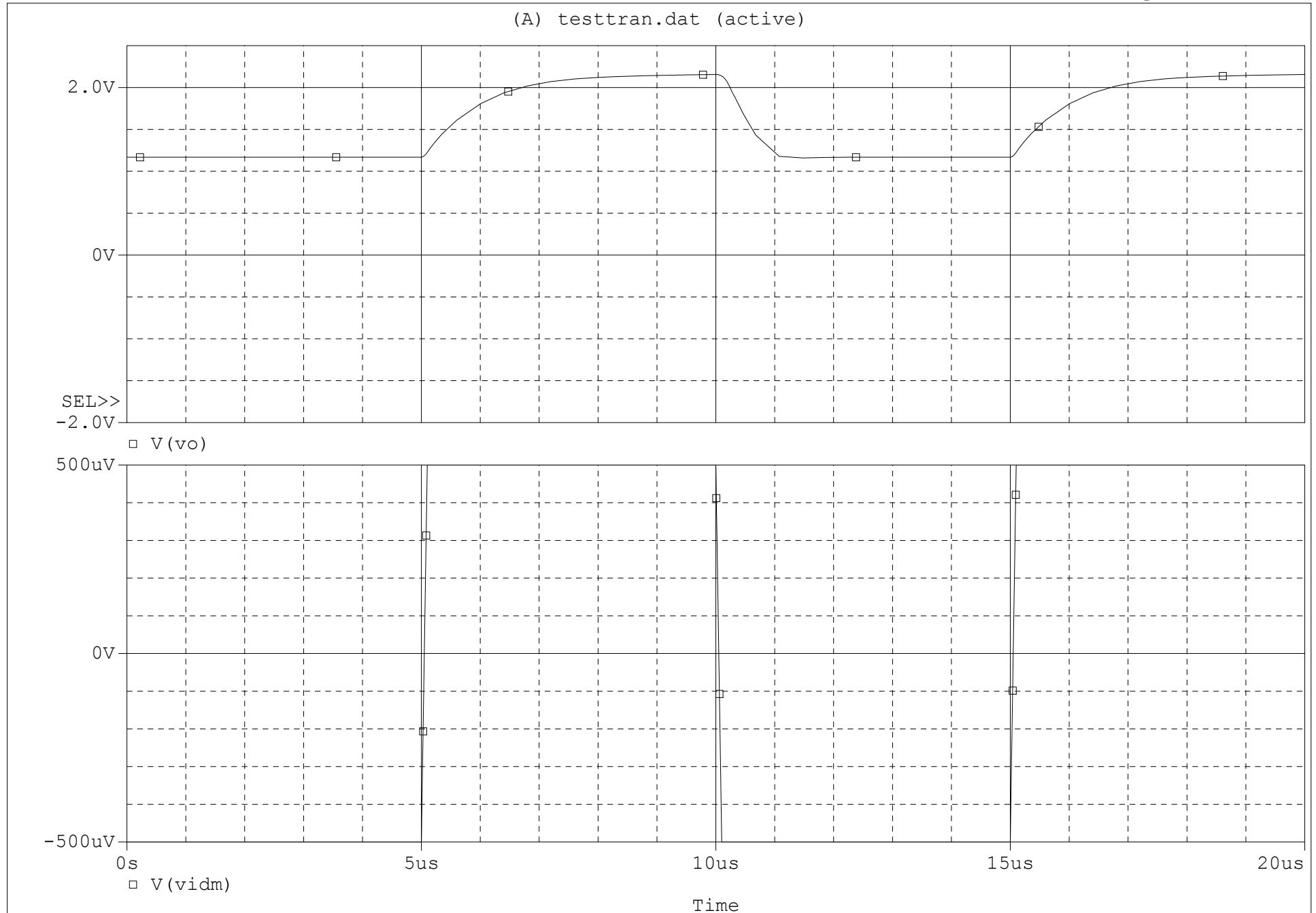




A1: (255.190M, 442.351m) A2: (1.0000K, 60.788) DIFF (A): (255.189M, -60.346)



A1: (0.000, 1.3125) A2: (0.000, 1.3125) DIFF(A): (0.000, 0.000)



```
•
**** 11/21/18 15:51:48 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testac" [ C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1
\testac.sim ]

****      CIRCUIT DESCRIPTION

*****

** Creating circuit file "testac.cir"
** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIONS

*Libraries:
* Profile Libraries :
* Local Libraries :
.LIB "//gaia/chakraba/models CMOS all.lib"
.LIB ".././../opamp telescopicn-pspicefiles/opamp telescopicn.lib"
* From [PSPICE NETLIST] section of C:\Users\chakraba\cdssetup\OrCAD_PSpice\17.2.0\PSpice.ini file:
.lib "nom.lib"

*Analysis directives:
.AC DEC 10 1k 1g
.OP
.OPTIONS ADVCONV
.OPTIONS NUMDGT= 5
.OPTIONS RELTOL= 0.0001
.PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
.INC "../SCHEMATIC1.net"

**** INCLUDING SCHEMATIC1.net ****
* source OPAMP TELESCOPICN
M M1          VD1 VIP VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M2          VD2 VIN VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M5          VTAIL VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
```

```

+ M={m5}
M M6          VBIAS VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m6}
M M3          VG3 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
M M4          VD4 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
I Ibias          VDDA VBIAS DC {ibias}
V Vdda          VDDA 0 {vdda}
V Vssa          VSSA 0 {vssa}
V VSdm          VIDM 0 DC 0 AC 1
+PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
C CL          VSSA VO {cl} TC=0,0
E Eip          VIP VCMIN VIDM VSSA 0.5
E Eicm          VCMIN VSSA VICM VSSA 1
E Ein          VIN VCMIN VIDM VSSA -0.5
V VScm          VICM 0 DC {vidc} AC 0
+PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
M M3c          VG3C VG3C VG3 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M4c          VO VG3C VD4 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M2c          VO VG1C VD2 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1c          VG3C VG1C VD1 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1cb          VG1C VG1C VTAIL VSSA N35
+ L={l1cb}
+ W={w1cb}
+ M={m1cb}
I Ibiasc          VDDA VG1C DC {ibiasc}
.PARAM w1cb=8.5u l3=3u w3=500u m1c=70 l3c={l3} vstep=1m per=10us cl=2pf vs1=
+ {(vstep/2)*(-1)} m6=0.9 vs2={vstep/2} w6=41u vidc=1.8 vssa=0.0 l6=0.28u m5=5
+ ibias=850u m3=150 ibiasc={ibias} tr={0.01*per} l1c={l1} td={per/2} vdda=3.0
+ m1=105 w3c={w3} w1c={w1} l1cb={l1} pw={per/2 - tr} m3c=60 l1=0.52u m1cb=10
+ w1=45u

```

**** RESUMING testac.cir ****
.END

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Ps = 0 is less than W

INFO(ORPSIM-15454): Model N35: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P35: Using BSIM VERSION 3.1 or lower

•

**** 11/21/18 15:51:48 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** MOSFET MODEL PARAMETERS

	N35	P35
	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	.500817	-.73241
KP	258.985800E-06	258.985800E-06
GAMMA	0	0
LAMBDA	0	0
RSH	3.3	2.6
IS	1.000000E-15	1.000000E-15
JS	100.000000E-06	100.000000E-06
PB	.76131	.99
PBSW	.99	.99
CJ	1.025196E-03	1.413411E-03
CJSW	304.889800E-12	413.447500E-12
MJ	.317902	.554975
MJSW	.129984	.359071
CGSO	284.000000E-12	317.000000E-12
CGDO	284.000000E-12	317.000000E-12
CGBO	1.000000E-12	1.000000E-12
TOX	8.000000E-09	8.000000E-09
XJ	100.000000E-09	100.000000E-09
UCRIT	10.000000E+03	10.000000E+03
DELTA	.01	.01
DIOMOD	2	2
K1	.560441	.437215
K2	.018158	-.015375

LETA	0	0
WETA	0	0
U0	420.4579	156.9094
XPART	.5	.5
VTH0	.500817	-.73241
K3	1.000000E-03	48.56546
W0	100.000000E-09	6.212362E-06
NLX	191.724900E-09	181.412800E-09
DVT0	3.668407	.837146
DVT1	.928603	.338643
UA	851.169300E-15	100.000000E-12
UB	1.453932E-18	2.067254E-18
UC	29.918750E-12	-15.668900E-12
VSAT	191.549500E+03	200.000000E+03
RDSW	712.8164	1.978024E+03
VOFF	-.080063	-.110788
NFACTOR	1.337384	1.671477
PCLM	1.201836	4.17521
PDIBL1	.998253	.010832
PDIBL2	6.597790E-03	2.223514E-03
DROUT	1	.067443
PSCBE1	7.195354E+09	18.801350E+09
PSCBE2	500.000000E-12	500.000000E-12
A0	1.237091	.589254
A1	0	913.214300E-06
A2	.386458	.415044
NPEAK	220.000000E+15	85.200000E+15
LDD	0	0
LITL	48.989790E-09	48.989790E-09
UA1	4.310000E-09	4.310000E-09
UB1	-7.610000E-18	-7.610000E-18
UC1	-56.000000E-12	-56.000000E-12
PVAG	.010021	5.946197
KETA	7.802194E-03	-1.017019E-03
ETA0	.180933	.023149
ETAB	4.990909E-03	.022032
K3B	.513871	-5
DVT2	-.257373	-.022621
DSUB	.441464	.63646
MOBMOD	1	1
AGS	.170423	.307773
DVT1W	0	0
DVT2W	0	0
PRWG	.125035	.01057
PRWB	-.097102	.063346
PDIBLCB	.098831	-1.000000E-03
DWG	-4.483031E-09	-17.734010E-09
DWB	11.254670E-09	13.335540E-09
B0	575.674000E-09	3.190353E-06
B1	5.000000E-06	5.000000E-06

LINT	-2.566383E-09	-38.879990E-09
WINT	87.880570E-09	85.463230E-09
WW	-1.221820E-15	-522.182000E-18
WWN	1.1907	1.215
DLC	-2.566383E-09	-38.879990E-09
DWC	87.880570E-09	85.463230E-09
CF	0	0
NOIA	100.000000E+18	9.900000E+18
NOIB	50.000000E+03	2.400000E+03
NOIC	-1.400000E-12	1.400000E-12
LKETA	-4.425361E-03	-8.660913E-03
WKETA	-916.373200E-06	543.174000E-06
PVTH0	-.022956	9.795915E-03
PRDSW	-109.7037	-123.4368
PK2	3.472875E-03	1.008100E-03
VTM	.025864	.025864
VERSION	3.1	3.1
PBSWG	.99	.99
MJSWG	.129984	.359071
CJSWG	182.000000E-12	44.200000E-12

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

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**** 11/21/18 15:51:48 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** SMALL SIGNAL BIAS SOLUTION TEMPERATURE = 27.000 DEG C

NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
(VO)	1.31248	(VD1)	1.12170	(VD2)	1.12170	(VD4)	2.24952
(VG3)	2.24952	(VIN)	1.80000	(VIP)	1.80000	(VDDA)	3.00000
(VG1C)	2.01744	(VG3C)	1.31248	(VICM)	1.80000	(VIDM)	0.00000
(VSSA)	0.00000	(VBIAS)	.85857	(VCMIN)	1.80000	(VTAIL)	.95637

VOLTAGE SOURCE CURRENTS
NAME CURRENT

V Vdda	-5.813E-03
V Vssa	5.813E-03
V VSdm	0.000E+00
V_VScm	0.000E+00

TOTAL POWER DISSIPATION 1.74E-02 WATTS

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**** 11/21/18 15:51:48 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

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

**** VOLTAGE-CONTROLLED VOLTAGE SOURCES

NAME	E_Eip	E_Eicm	E_Ein
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V-SOURCE	0.000E+00	1.800E+00	0.000E+00
I-SOURCE	0.000E+00	0.000E+00	0.000E+00

**** MOSFETS

NAME	M M1	M M2	M M5	M M6	M M3
MODEL	N35	N35	N35	N35	P35
ID	2.06E-03	2.06E-03	4.96E-03	8.50E-04	-2.06E-03
VGS	8.44E-01	8.44E-01	8.59E-01	8.59E-01	-7.50E-01
VDS	1.65E-01	1.65E-01	9.56E-01	8.59E-01	-7.50E-01
VBS	-9.56E-01	-9.56E-01	0.00E+00	0.00E+00	0.00E+00
VTH	8.27E-01	8.27E-01	5.71E-01	5.77E-01	-7.44E-01
VDSAT	7.09E-02	7.09E-02	2.14E-01	2.11E-01	-7.60E-02
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	4.36E-02	4.36E-02	2.82E-02	4.97E-03	4.23E-02
GDS	1.52E-03	1.52E-03	2.47E-03	4.40E-04	8.69E-05
GMB	9.02E-03	9.02E-03	7.17E-03	1.26E-03	9.37E-03
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	1.34E-12	1.34E-12	5.82E-14	1.05E-14	2.38E-11
CGDOV	1.34E-12	1.34E-12	5.82E-14	1.05E-14	2.38E-11
CGBOV	5.20E-19	5.20E-19	2.80E-19	2.80E-19	3.00E-18

Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges

DQGDVGB	8.71E-12	8.71E-12	3.24E-13	5.84E-14	5.42E-10
DQGDVDB	-1.29E-12	-1.29E-12	-4.64E-14	-8.35E-15	-2.38E-11
DQGDVSB	-6.45E-12	-6.45E-12	-2.60E-13	-4.67E-14	-3.84E-10
DQDDVGB	-3.58E-12	-3.58E-12	-1.42E-13	-2.55E-14	-2.04E-10
DQDDVDB	1.33E-12	1.33E-12	5.33E-14	9.59E-15	2.38E-11
DQDDVSB	2.73E-12	2.73E-12	1.11E-13	2.01E-14	2.23E-10
DQBDVGB	-1.54E-12	-1.54E-12	-4.07E-14	-7.32E-15	-1.34E-10
DQBDVDB	-3.04E-14	-3.04E-14	-2.20E-15	-3.98E-16	-7.34E-15
DQBDVSB	-3.51E-13	-3.51E-13	-2.13E-14	-3.85E-15	-8.50E-11

NAME	M M4	M M3c	M M4c	M M2c	M M1c
MODEL	P35	P35	P35	N35	N35
ID	-2.06E-03	-2.06E-03	-2.06E-03	2.06E-03	2.06E-03
VGS	-7.50E-01	-9.37E-01	-9.37E-01	8.96E-01	8.96E-01
VDS	-7.50E-01	-9.37E-01	-9.37E-01	1.91E-01	1.91E-01
VBS	0.00E+00	7.50E-01	7.50E-01	-1.12E+00	-1.12E+00
VTH	-7.44E-01	-8.86E-01	-8.86E-01	8.60E-01	8.60E-01
VDSAT	-7.60E-02	-1.06E-01	-1.06E-01	8.04E-02	8.04E-02
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	4.23E-02	3.61E-02	3.61E-02	4.10E-02	4.10E-02
GDS	8.69E-05	7.54E-05	7.54E-05	1.31E-03	1.31E-03
GMB	9.37E-03	5.73E-03	5.73E-03	8.02E-03	8.02E-03
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	2.38E-11	9.51E-12	9.51E-12	8.95E-13	8.95E-13
CGDOV	2.38E-11	9.51E-12	9.51E-12	8.95E-13	8.95E-13
CGBOV	3.00E-18	3.00E-18	3.00E-18	5.20E-19	5.20E-19

Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges

DQGDVGB	5.42E-10	2.71E-10	2.71E-10	6.32E-12	6.32E-12
DQGDVDB	-2.38E-11	-9.52E-12	-9.52E-12	-8.52E-13	-8.52E-13
DQGDVSB	-3.84E-10	-2.31E-10	-2.31E-10	-4.94E-12	-4.94E-12
DQDDVGB	-2.04E-10	-1.20E-10	-1.20E-10	-2.67E-12	-2.67E-12
DQDDVDB	2.38E-11	9.51E-12	9.51E-12	8.81E-13	8.81E-13
DQDDVSB	2.23E-10	1.28E-10	1.28E-10	2.15E-12	2.15E-12
DQBDVGB	-1.34E-10	-3.17E-11	-3.17E-11	-9.68E-13	-9.68E-13
DQBDVDB	-7.34E-15	-2.95E-15	-2.95E-15	-1.96E-14	-1.96E-14
DQBDVSB	-8.50E-11	-3.36E-11	-3.36E-11	-2.50E-13	-2.50E-13

NAME	M M1cb
MODEL	N35
ID	8.50E-04
VGS	1.06E+00
VDS	1.06E+00
VBS	-9.56E-01
VTH	8.12E-01
VDSAT	2.21E-01
Lin0/Sat1	-1.00E+00
if	-1.00E+00
ir	-1.00E+00
TAU	-1.00E+00
GM	6.00E-03
GDS	1.19E-04
GMB	1.24E-03
CBD	0.00E+00
CBS	0.00E+00
CGSOV	2.41E-14
CGDOV	2.41E-14
CGBOV	5.20E-19

Derivatives of gate (dQg/dVxy) and bulk (dQb/dVxy) charges

DQGDVGB	1.98E-13
DQGDVDB	-2.19E-14
DQGDVSB	-1.69E-13
DQDDVGB	-8.66E-14
DQDDVDB	2.29E-14
DQDDVSB	7.69E-14
DQBDVGB	-2.47E-14
DQBDVDB	-2.92E-16
DQBDVSB	-8.91E-15

JOB CONCLUDED

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**** 11/21/18 15:51:48 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** JOB STATISTICS SUMMARY

Total job time (using Solver 1) = .11

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**** 11/21/18 16:04:07 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [ C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1
\testac.sim ]

****      CIRCUIT DESCRIPTION

*****

** Creating circuit file "testac.cir"
** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIONS

*Libraries:
* Profile Libraries :
* Local Libraries :
.LIB "//gaia/chakraba/models CMOS all.lib"
.LIB ".././.././opamp telescopicn-pspicefiles/opamp telescopicn.lib"
* From [PSPICE NETLIST] section of C:\Users\chakraba\cdssetup\OrCAD_PSpice\17.2.0\PSpice.ini file:
.lib "nom.lib"

*Analysis directives:
.DC LIN V VSdm 0 3.0 0.5
.OPTIONS ADVCONV
.OPTIONS NUMDGT= 5
.OPTIONS RELTOL= 0.0001
.PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
.INC "../SCHEMATIC1.net"

**** INCLUDING SCHEMATIC1.net ****
* source OPAMP TELESCOPICN
M M1          VD1 VIP VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M2          VD2 VIN VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M5          VTAIL VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m5}
```

```

M M6          VBIAS VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m6}
M M3          VG3 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
M M4          VD4 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
I Ibias       VDDA VBIAS DC {ibias}
V Vdda        VDDA 0 {vdda}
V Vssa        VSSA 0 {vssa}
V VSdm        VIDM 0 DC 0 AC 1
+PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
C CL          VSSA VO {cl} TC=0,0
E Eip         VIP VCMIN VIDM VSSA 0.5
E Eicm        VCMIN VSSA VICM VSSA 1
E Ein         VIN VCMIN VIDM VSSA -0.5
V VScm        VICM 0 DC {vidc} AC 0
+PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
M M3c         VG3C VG3C VG3 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M4c         VO VG3C VD4 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M2c         VO VG1C VD2 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1c         VG3C VG1C VD1 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1cb        VG1C VG1C VTAIL VSSA N35
+ L={l1cb}
+ W={w1cb}
+ M={m1cb}
I Ibiasc      VDDA VG1C DC {ibiasc}
.PARAM w1cb=8.5u l3=3u w3=500u m1c=70 l3c={l3} vstep=1m per=10us cl=2pf vs1=
+ {(vstep/2)*(-1)} m6=0.9 vs2={ (vstep/2)} w6=41u vidc=1.8 vssa=0.0 l6=0.28u m5=5
+ ibias=850u m3=150 ibiasc={ibias} tr={0.01*per} l1c={l1} td={per/2} vdda=3.0
+ m1=105 w3c={w3} w1c={w1} l1cb={l1} pw={per/2 - tr} m3c=60 l1=0.52u m1cb=10
+ w1=45u

```

**** RESUMING testac.cir ****
.END

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Ps = 0 is less than W

INFO(ORPSIM-15454): Model N35: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P35: Using BSIM VERSION 3.1 or lower

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**** 11/21/18 16:04:07 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** MOSFET MODEL PARAMETERS

	N35	P35
	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	.500817	-.73241
KP	258.985800E-06	258.985800E-06
GAMMA	0	0
LAMBDA	0	0
RSH	3.3	2.6
IS	1.000000E-15	1.000000E-15
JS	100.000000E-06	100.000000E-06
PB	.76131	.99
PBSW	.99	.99
CJ	1.025196E-03	1.413411E-03
CJSW	304.889800E-12	413.447500E-12
MJ	.317902	.554975
MJSW	.129984	.359071
CGSO	284.000000E-12	317.000000E-12
CGDO	284.000000E-12	317.000000E-12
CGBO	1.000000E-12	1.000000E-12
TOX	8.000000E-09	8.000000E-09
XJ	100.000000E-09	100.000000E-09
UCRIT	10.000000E+03	10.000000E+03
DELTA	.01	.01
DIOMOD	2	2
K1	.560441	.437215
K2	.018158	-.015375
LETA	0	0

WETA	0	0
U0	420.4579	156.9094
XPART	.5	.5
VTH0	.500817	-.73241
K3	1.000000E-03	48.56546
W0	100.000000E-09	6.212362E-06
NLX	191.724900E-09	181.412800E-09
DVT0	3.668407	.837146
DVT1	.928603	.338643
UA	851.169300E-15	100.000000E-12
UB	1.453932E-18	2.067254E-18
UC	29.918750E-12	-15.668900E-12
VSAT	191.549500E+03	200.000000E+03
RDSW	712.8164	1.978024E+03
VOFF	-.080063	-.110788
NFACTOR	1.337384	1.671477
PCLM	1.201836	4.17521
PDIBL1	.998253	.010832
PDIBL2	6.597790E-03	2.223514E-03
DROUT	1	.067443
PSCBE1	7.195354E+09	18.801350E+09
PSCBE2	500.000000E-12	500.000000E-12
A0	1.237091	.589254
A1	0	913.214300E-06
A2	.386458	.415044
NPEAK	220.000000E+15	85.200000E+15
LDD	0	0
LITL	48.989790E-09	48.989790E-09
UA1	4.310000E-09	4.310000E-09
UB1	-7.610000E-18	-7.610000E-18
UC1	-56.000000E-12	-56.000000E-12
PVAG	.010021	5.946197
KETA	7.802194E-03	-1.017019E-03
ETA0	.180933	.023149
ETAB	4.990909E-03	.022032
K3B	.513871	-5
DVT2	-.257373	-.022621
DSUB	.441464	.63646
MOBMOD	1	1
AGS	.170423	.307773
DVT1W	0	0
DVT2W	0	0
PRWG	.125035	.01057
PRWB	-.097102	.063346
PDIBLCB	.098831	-1.000000E-03
DWG	-4.483031E-09	-17.734010E-09
DWB	11.254670E-09	13.335540E-09
B0	575.674000E-09	3.190353E-06
B1	5.000000E-06	5.000000E-06
LINT	-2.566383E-09	-38.879990E-09

WINT	87.880570E-09	85.463230E-09
WW	-1.221820E-15	-522.182000E-18
WWN	1.1907	1.215
DLC	-2.566383E-09	-38.879990E-09
DWC	87.880570E-09	85.463230E-09
CF	0	0
NOIA	100.000000E+18	9.900000E+18
NOIB	50.000000E+03	2.400000E+03
NOIC	-1.400000E-12	1.400000E-12
LKETA	-4.425361E-03	-8.660913E-03
WKETA	-916.373200E-06	543.174000E-06
PVTH0	-.022956	9.795915E-03
PRDSW	-109.7037	-123.4368
PK2	3.472875E-03	1.008100E-03
VTM	.025864	.025864
VERSION	3.1	3.1
PBSWG	.99	.99
MJSWG	.129984	.359071
CJSWG	182.000000E-12	44.200000E-12

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

JOB CONCLUDED

•
**** 11/21/18 16:04:07 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testac" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testac.sim]

**** JOB STATISTICS SUMMARY

• Total job time (using Solver 1) = .03

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**** 11/21/18 16:09:32 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testtran" [ C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schemati
c1\testtran.s

****      CIRCUIT DESCRIPTION

*****

** Creating circuit file "testtran.cir"
** WARNING: THIS AUTOMATICALLY GENERATED FILE MAY BE OVERWRITTEN BY SUBSEQUENT SIMULATIONS

*Libraries:
* Profile Libraries :
* Local Libraries :
.LIB "//gaia/chakraba/models CMOS all.lib"
.LIB ".././../opamp telescopicn-pspicefiles/opamp telescopicn.lib"
* From [PSPICE NETLIST] section of C:\Users\chakraba\cdssetup\OrCAD_PSpice\17.2.0\PSpice.ini file:
.lib "nom.lib"

*Analysis directives:
.TRAN 0 20us 0 10us
.OPTIONS ADVCONV
.PROBE64 V(alias(*)) I(alias(*)) W(alias(*)) D(alias(*)) NOISE(alias(*))
.INC "../SCHEMATIC1.net"

**** INCLUDING SCHEMATIC1.net ****
* source OPAMP TELESCOPICN
M M1          VD1 VIP VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M2          VD2 VIN VTAIL VSSA N35
+ L={l1}
+ W={w1}
+ M={m1}
M M5          VTAIL VBIAS VSSA VSSA N35
+ L={l6}
+ W={w6}
+ M={m5}
M M6          VBIAS VBIAS VSSA VSSA N35
+ L={l6}
```

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+ W={w6}
+ M={m6}
M M3          VG3 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
M M4          VD4 VG3 VDDA VDDA P35
+ L={l3}
+ W={w3}
+ M={m3}
I Ibias       VDDA VBIAS DC {ibias}
V Vdda        VDDA 0 {vdda}
V Vssa        VSSA 0 {vssa}
V VSdm        VIDM 0 DC 0 AC 1
+PULSE {vs1} {vs2} {td} {tr} {tr} {pw} {per}
C CL          VSSA VO {cl} TC=0,0
E Eip         VIP VCMIN VIDM VSSA 0.5
E Eicm        VCMIN VSSA VICM VSSA 1
E Ein         VIN VCMIN VIDM VSSA -0.5
V VScm        VICM 0 DC {vidc} AC 0
+PULSE {vidc} {vidc} {td+1} {tr} {tr} {pw} {per}
M M3c         VG3C VG3C VG3 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M4c         VO VG3C VD4 VDDA P35
+ L={l3c}
+ W={w3c}
+ M={m3c}
M M2c         VO VG1C VD2 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1c         VG3C VG1C VD1 VSSA N35
+ L={l1c}
+ W={w1c}
+ M={m1c}
M M1cb        VG1C VG1C VTAIL VSSA N35
+ L={l1cb}
+ W={w1cb}
+ M={m1cb}
I Ibiasc      VDDA VG1C DC {ibiasc}
.PARAM w1cb=8.5u l3=3u w3=500u m1c=70 l3c={l3} vstep=1m per=10us cl=2pf vs1=
+ {(vstep/2)*(-1)} m6=0.9 vs2={vstep/2} w6=41u vidc=1.8 vssa=0.0 l6=0.28u m5=5
+ ibias=850u m3=150 ibiasc={ibias} tr={0.01*per} l1c={l1} td={per/2} vdda=3.0
+ m1=105 w3c={w3} w1c={w1} l1cb={l1} pw={per/2 - tr} m3c=60 l1=0.52u m1cb=10
+ w1=45u

```

```

**** RESUMING testtran.cir ****
.END

```

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M6, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M2c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1c, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M3c, model P35: Ps = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Pd = 0 is less than W
WARNING(ORPSIM-15235): Mosfet M_M4c, model P35: Ps = 0 is less than W
INFO(ORPSIM-15454): Model N35: Using BSIM VERSION 3.1 or lower

INFO(ORPSIM-15454): Model P35: Using BSIM VERSION 3.1 or lower

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**** 11/21/18 16:09:32 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testtran" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testtran.s

**** MOSFET MODEL PARAMETERS

	N35	P35
	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	.500817	-.73241
KP	258.985800E-06	258.985800E-06
GAMMA	0	0
LAMBDA	0	0
RSH	3.3	2.6
IS	1.000000E-15	1.000000E-15
JS	100.000000E-06	100.000000E-06
PB	.76131	.99
PBSW	.99	.99
CJ	1.025196E-03	1.413411E-03
CJSW	304.889800E-12	413.447500E-12
MJ	.317902	.554975
MJSW	.129984	.359071
CGSO	284.000000E-12	317.000000E-12
CGDO	284.000000E-12	317.000000E-12
CGBO	1.000000E-12	1.000000E-12
TOX	8.000000E-09	8.000000E-09
XJ	100.000000E-09	100.000000E-09
UCRIT	10.000000E+03	10.000000E+03
DELTA	.01	.01
DIOMOD	2	2
K1	.560441	.437215
K2	.018158	-.015375
LETA	0	0
WETA	0	0
U0	420.4579	156.9094

XPART	.5	.5
VTH0	.500817	-.73241
K3	1.000000E-03	48.56546
W0	100.000000E-09	6.212362E-06
NLX	191.724900E-09	181.412800E-09
DVT0	3.668407	.837146
DVT1	.928603	.338643
UA	851.169300E-15	100.000000E-12
UB	1.453932E-18	2.067254E-18
UC	29.918750E-12	-15.668900E-12
VSAT	191.549500E+03	200.000000E+03
RDSW	712.8164	1.978024E+03
VOFF	-.080063	-.110788
NFACTOR	1.337384	1.671477
PCLM	1.201836	4.17521
PDIBL1	.998253	.010832
PDIBL2	6.597790E-03	2.223514E-03
DROUT	1	.067443
PSCBE1	7.195354E+09	18.801350E+09
PSCBE2	500.000000E-12	500.000000E-12
A0	1.237091	.589254
A1	0	913.214300E-06
A2	.386458	.415044
NPEAK	220.000000E+15	85.200000E+15
LDD	0	0
LITL	48.989790E-09	48.989790E-09
UA1	4.310000E-09	4.310000E-09
UB1	-7.610000E-18	-7.610000E-18
UC1	-56.000000E-12	-56.000000E-12
PVAG	.010021	5.946197
KETA	7.802194E-03	-1.017019E-03
ETA0	.180933	.023149
ETAB	4.990909E-03	.022032
K3B	.513871	-5
DVT2	-.257373	-.022621
DSUB	.441464	.63646
MOBMOD	1	1
AGS	.170423	.307773
DVT1W	0	0
DVT2W	0	0
PRWG	.125035	.01057
PRWB	-.097102	.063346
PDIBLCB	.098831	-1.000000E-03
DWG	-4.483031E-09	-17.734010E-09
DWB	11.254670E-09	13.335540E-09
B0	575.674000E-09	3.190353E-06
B1	5.000000E-06	5.000000E-06
LINT	-2.566383E-09	-38.879990E-09
WINT	87.880570E-09	85.463230E-09
WW	-1.221820E-15	-522.182000E-18

WWN	1.1907	1.215
DLC	-2.566383E-09	-38.879990E-09
DWC	87.880570E-09	85.463230E-09
CF	0	0
NOIA	100.000000E+18	9.900000E+18
NOIB	50.000000E+03	2.400000E+03
NOIC	-1.400000E-12	1.400000E-12
LKETA	-4.425361E-03	-8.660913E-03
WKETA	-916.373200E-06	543.174000E-06
PVTH0	-.022956	9.795915E-03
PRDSW	-109.7037	-123.4368
PK2	3.472875E-03	1.008100E-03
VTM	.025864	.025864
VERSION	3.1	3.1
PBSWG	.99	.99
MJSWG	.129984	.359071
CJSWG	182.000000E-12	44.200000E-12

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model N35 is invalid - Ignored

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M5, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M1cb, model N35: Ps = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Pd = 0 is less than W

WARNING(ORPSIM-15235): Mosfet M_M3, model P35: Ps = 0 is less than W

WARNING(ORPSIM-15236): Parameter XL in model P35 is invalid - Ignored

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**** 11/21/18 16:09:32 ***** PSpice 17.2.0 (March 2016) ***** ID# 0 *****

** Profile: "SCHEMATIC1-testtran" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testtran.s

**** INITIAL TRANSIENT SOLUTION TEMPERATURE = 27.000 DEG C

NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE	NODE	VOLTAGE
(VO)	1.1683	(VD1)	1.1215	(VD2)	1.1079	(VD4)	2.2493
(VG3)	2.2495	(VIN)	1.8003	(VIP)	1.7998	(VDDA)	3.0000
(VG1C)	2.0172	(VG3C)	1.3125	(VICM)	1.8000	(VIDM)	-500.0E-06
(VSSA)	0.0000	(VBIAS)	.8586	(VCMIN)	1.8000	(VTAIL)	.9562

VOLTAGE SOURCE CURRENTS
NAME CURRENT

V Vdda	-5.812E-03
V Vssa	5.812E-03
V VSdm	0.000E+00
V_VScm	0.000E+00

TOTAL POWER DISSIPATION 1.74E-02 WATTS

JOB CONCLUDED

**** 11/21/18 16:09:32 **** PSpice 17.2.0 (March 2016) **** ID# 0 ****

** Profile: "SCHEMATIC1-testtran" [C:\Users\chakraba\Desktop\opamp_telescopicN\opamp_telescopicn-pspicefiles\schematic1\testtran.s

**** JOB STATISTICS SUMMARY

Total job time (using Solver 1) = .06

Observation: I observed that there are difference in between hand calculation and simulated result due to some higher order effects which effects the simulated output but not in the hand calculation. I also noticed some important facts that the corner frequency or f_{p1} starts to roll of after certain value and at particular frequency, the gain curve touches the 0dB line. The unity gain bandwidth product is constant in between these tho points(corner freq and unity-gain freq) when the straight line has constant slope. Another thing is that, if the gain curve touches the 0 dB before reaching the second pole frequency, then the op-amp is stable at any gain and I have got the second pole frequency after the gain curve touches 0 dB, So the designed op-amp is stable. I changed the w_1 and l_1 accordingly to meet the specification for unity gain bandwidth, phase margin as all these parameters effect greatly to calculate parasitic capacitances. There is also a trade-off in between gain and bandwidth. If gain increases then bandwidth decreases as the product of these two parameters are constant.