Common Source Amplifier

Specification:

Gain(Av)=40

Rout=150 KΩ

BW=25 MHz

Calculation:

- **Formula Used**

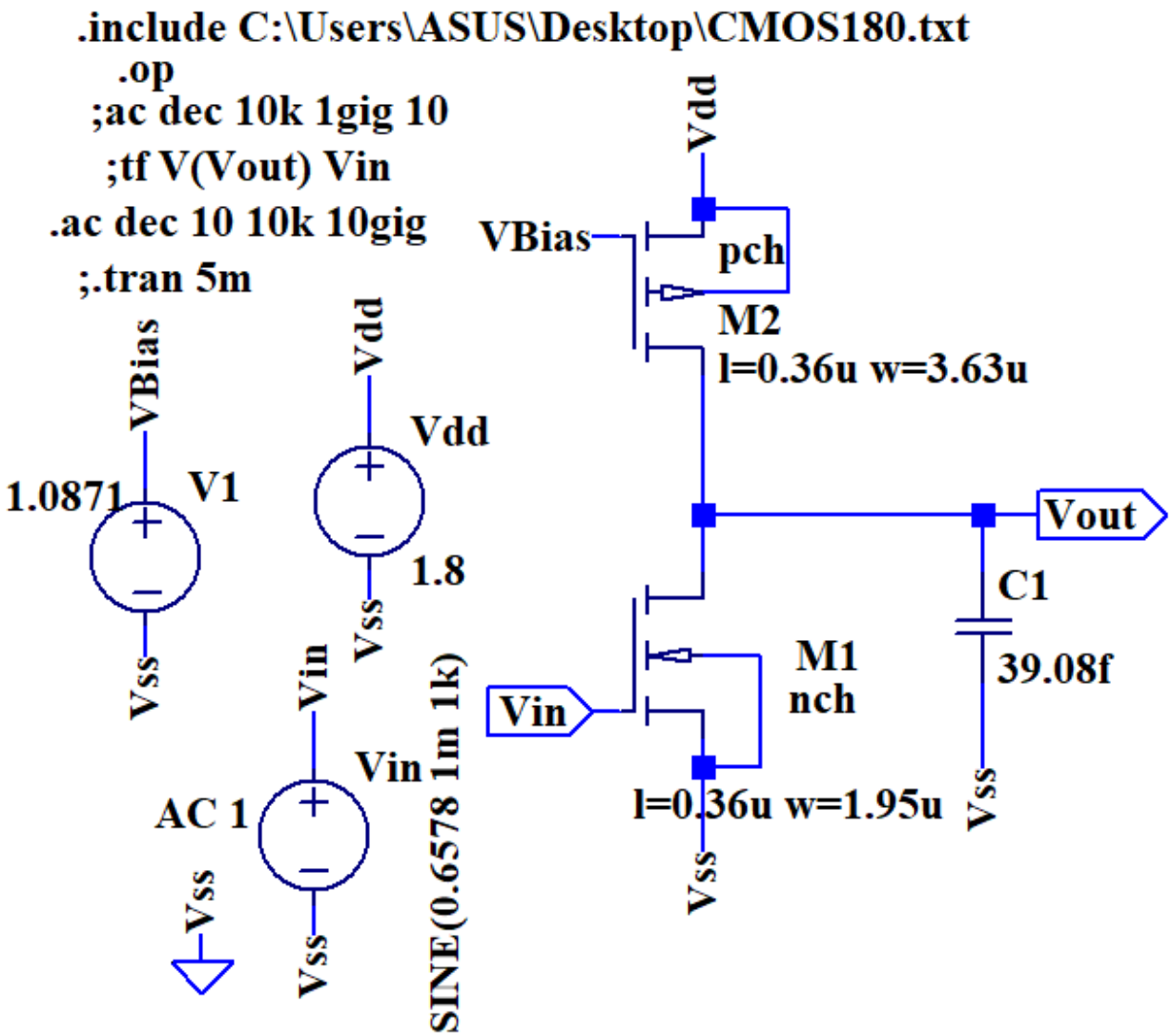
- BW(3dB freq) $= \frac{1}{2\pi . Rout . CL}$ Av=gm.Rout
- Rout= ro1 // ro2

- CL=42.44 fF
- gm/id=10 (Choose)
- gm=0.266 mS
- Id=26.6 µA
- gm/gds= 81.72 ……from chart id/w=13.6
- gds=3.25 µS W1=1.95 µm
- Ro1=307.21 KΩ Vgs1=657.8mV

Continue….

- Ro2=293.12 K Ω
- gds2=3.41 µS
- $(Id/gds)_2$=7.8
- $(gm/id)_2$= 7.106 …… from chart
- $(Id/w)_2$=7.312 …… from chart
- Vgs2=712.9 mV
- W2= 3.63 µm

SIMULATION


.include C:\Users\ASUS\Desktop\CMOS180.txt
.op
;ac dec 10k 1gig 10
;tf V(Vout) Vin
.ac dec 10 10k 10gig
;.tran 5m
VBias
1.0871
V1
Vss
Vdd
Vdd
1.8
Vss
Vin
Vin
AC 1
Vss
Vss
SINE(0.6578 1m 1k)
Vdd
VBias
pch
M2
l=0.36u w=3.63u
Vout
C1
39.08f
M1
nch
Vin
l=0.36u w=1.95u
Vss
Vss

Some Changes

Internal capacitance at node Vout = cgd2 +cgd1(1+Av)

C(Vout) = 3.36 fF

So CL=42.44 f -3.36f = **39.08 fF**

Result And Conclusion

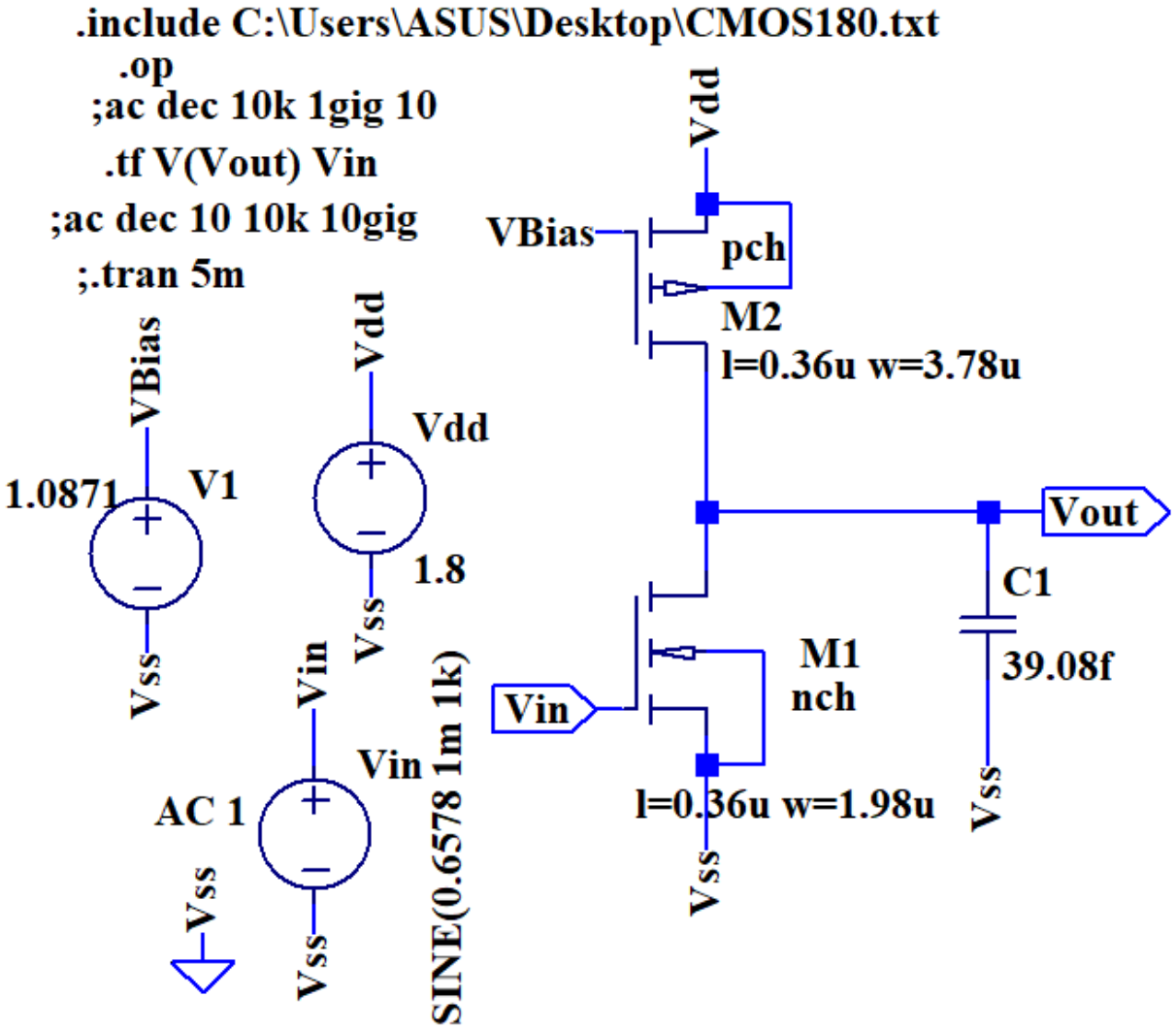
Simulated Value	Specifications
Av= 40.01 v/v	Av=40 v/v
BW=25.06 MHz	BW=25MHz
GBW=1.002 GHz	GBW=1 GHz
Rout=149.327 KΩ	Rout=150 KΩ
Id=26.73 µA	Id=26.6 µA
Vout(dc)=0.773 V	Vout(dc)=0.9 V

Spice Error Log File

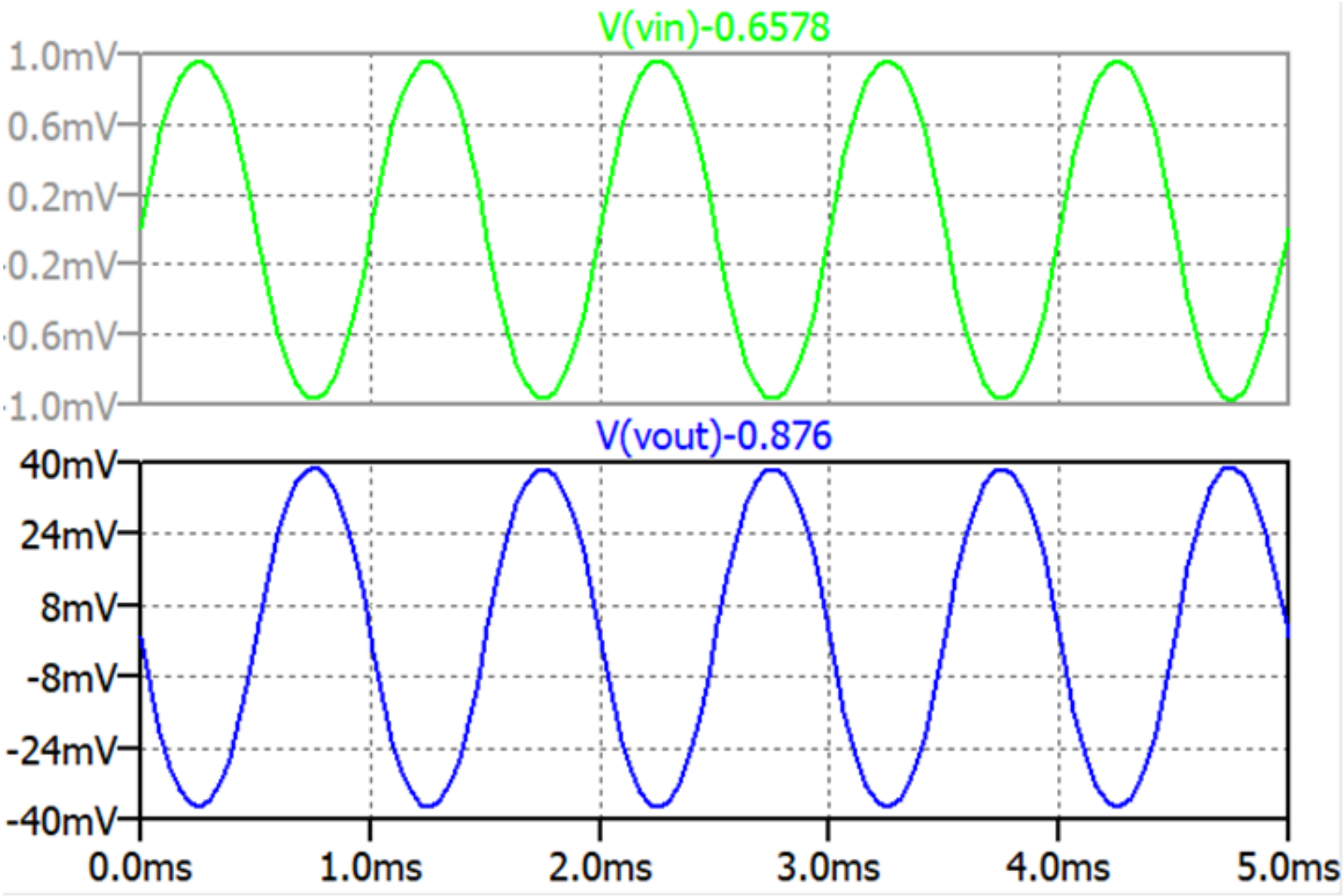
```
       --- Transfer Function ---

Transfer_function:            -40.0109       transfer
vin#Input_impedance:          1e+020         impedance
output_impedance_at_V(vout):  149327         impedance
```

```
Semiconductor Device Operating Points:
                                --- BSIM3 MOSFETS ---
Name:          m2             m1
Model:         pch            nch
Id:        -2.67e-05      2.67e-05
Vgs:       -7.13e-01      6.58e-01
Vds:       -1.03e+00      7.74e-01
Vbs:        0.00e+00      0.00e+00
Vth:       -4.48e-01      4.59e-01
Vdsat:     -2.19e-01      1.52e-01
Gm:         1.87e-04      2.68e-04
Gds:        3.21e-06      3.49e-06
Gmb         5.86e-05      7.00e-05
Cbd:        0.00e+00      0.00e+00
Cbs:        0.00e+00      0.00e+00
Cgsov:      2.38e-15      9.57e-16
Cgdov:      2.38e-15      9.57e-16
Cgbov:      2.98e-19      3.28e-19
dQgdVgb:    1.24e-14      6.48e-15
dQgdVdb:   -2.38e-15     -9.32e-16
dQgdVsb:   -9.67e-15     -5.23e-15
dQddVgb:   -2.39e-15     -9.63e-16
dQddVdb:    2.39e-15      9.60e-16
dQddVsb:    4.60e-18      4.49e-18
dQbdVgb:   -1.61e-15     -9.88e-16
dQbdVdb:   -5.20e-19      1.92e-18
dQbdVsb:   -7.20e-16     -4.05e-16
```

UNIT DEVICES

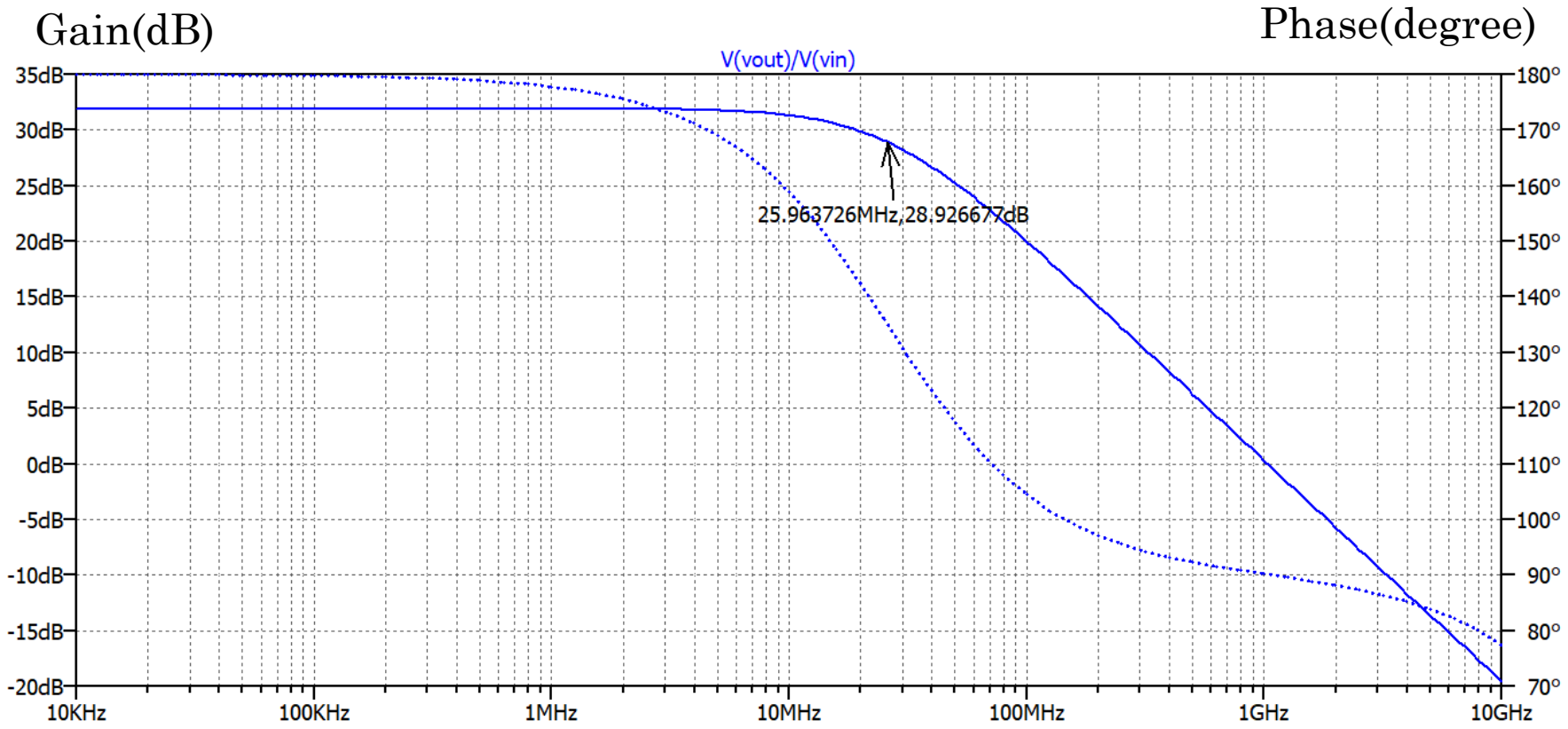


Transient Analysis



Vin(p-p)=2 mV Vout=78.88 mV Gain=39.44

FREQUENCY

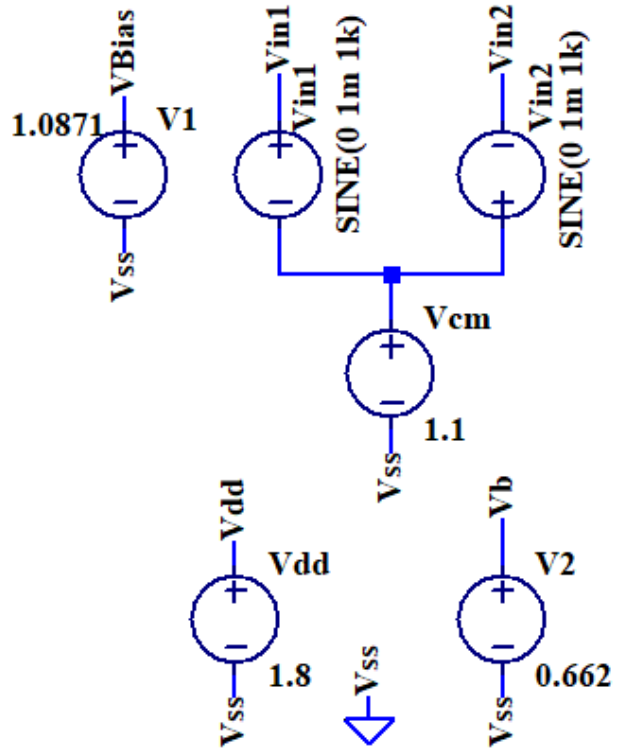


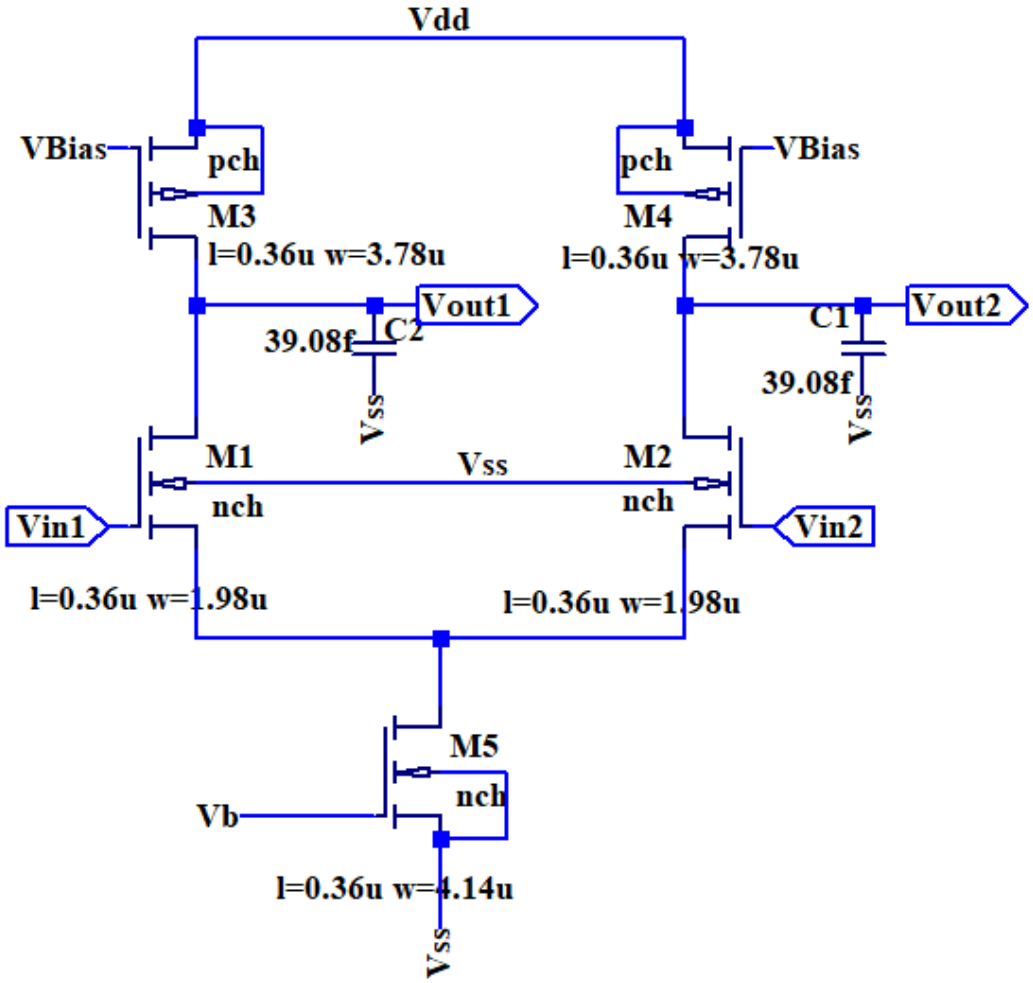
BW=25.96 MHz

Differential Pair

Using two Common Source Amplifier

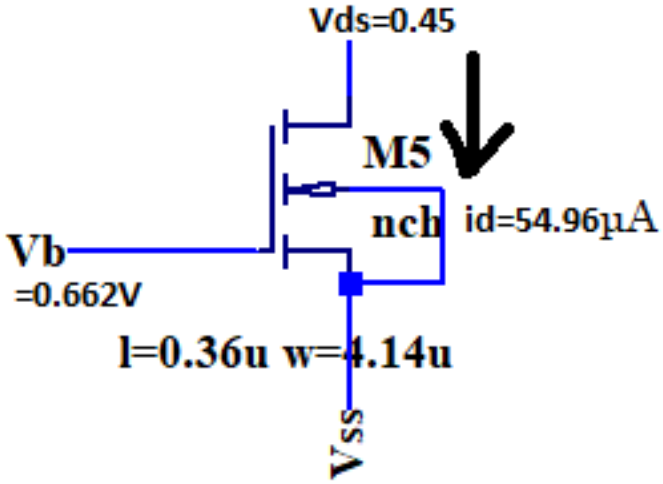
```
.include C:\Users\ASUS\Desktop\CMOS180.txt
  .op
 ;ac dec 10k 1gig 10
  .tf V(Vout1,Vout2) (Vin1,Vin2)
;ac dec 10 10k 10gig
 ;tran 5m
```





Calculation for Current Source

Id=54.96 µA
gm/id= 10 …(Choose)
Vgs=Vb=0.662
Id/w=13.41

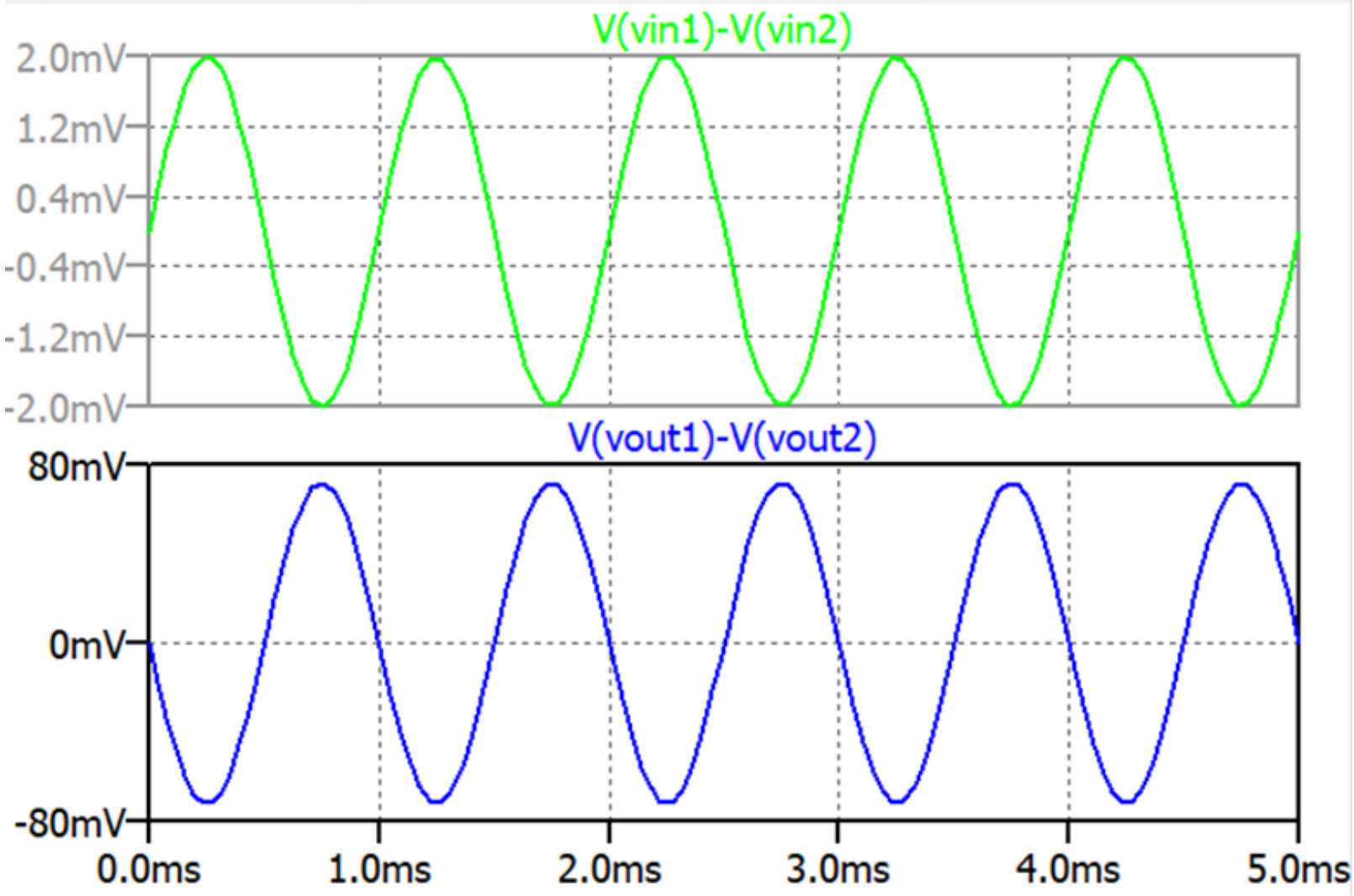


W5=4.09 µm
W5=4.14 µm …..for unit device

Result and Conclusion

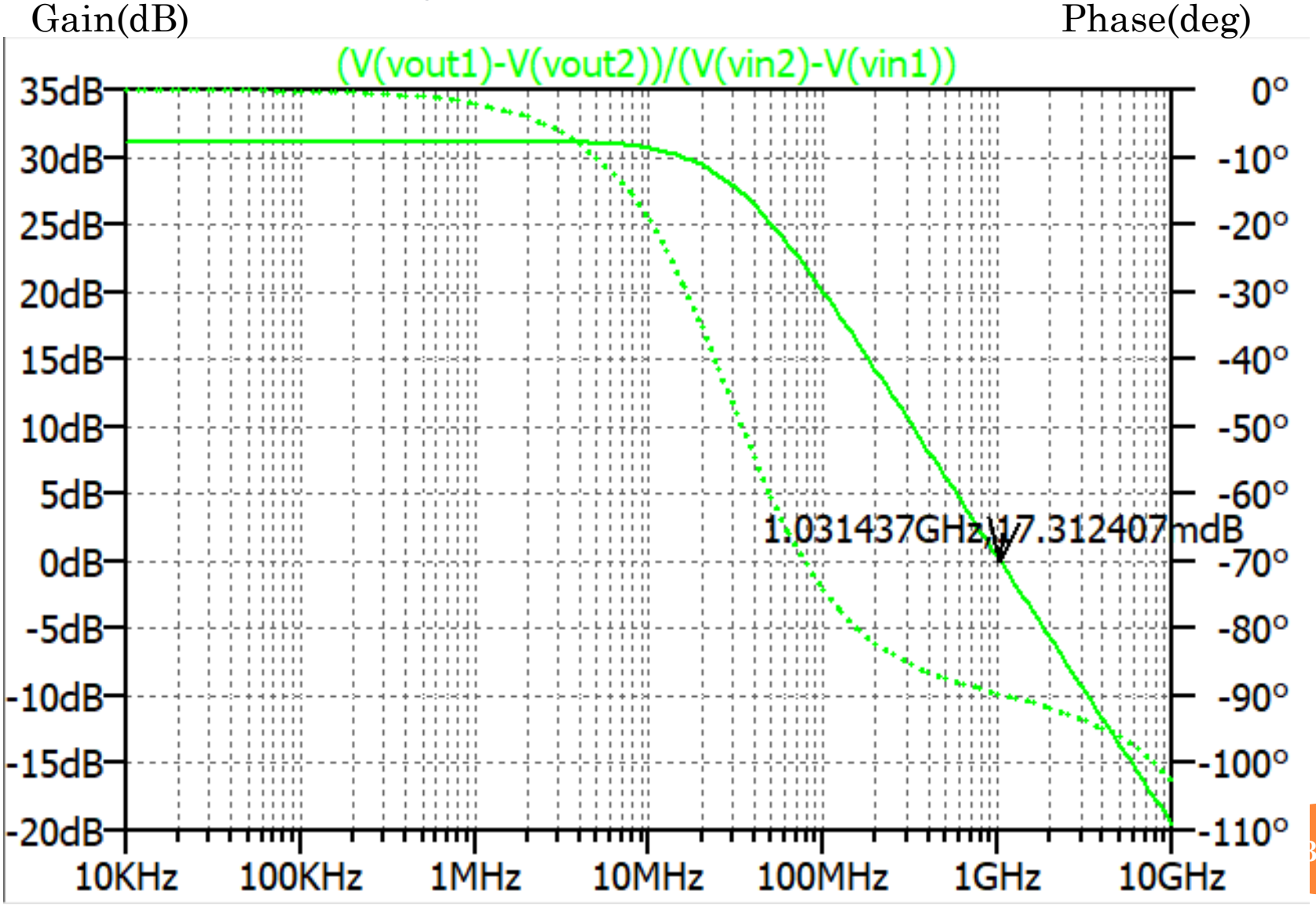
Simulated Value	Specifications
Av= 36.18 v/v	Av=40 v/v
BW=28.66 MHz	BW=25MHz
GBW=1.03 GHz	GBW=1 GHz
Rout=263.492 KΩ	
Iss= 54.46 µA	Iss= 54.96µA
Vout(dc)=0.949 V	Vout(dc)=0.9 V

Transient Analysis



Vin1-Vin2(pp)=4 mV Vout1-Vout2(pp)=144.56mV Gain=36.14

Frequency Response



Common Source Amplifier

Specs:
Av=40
Rout=93 KΩ

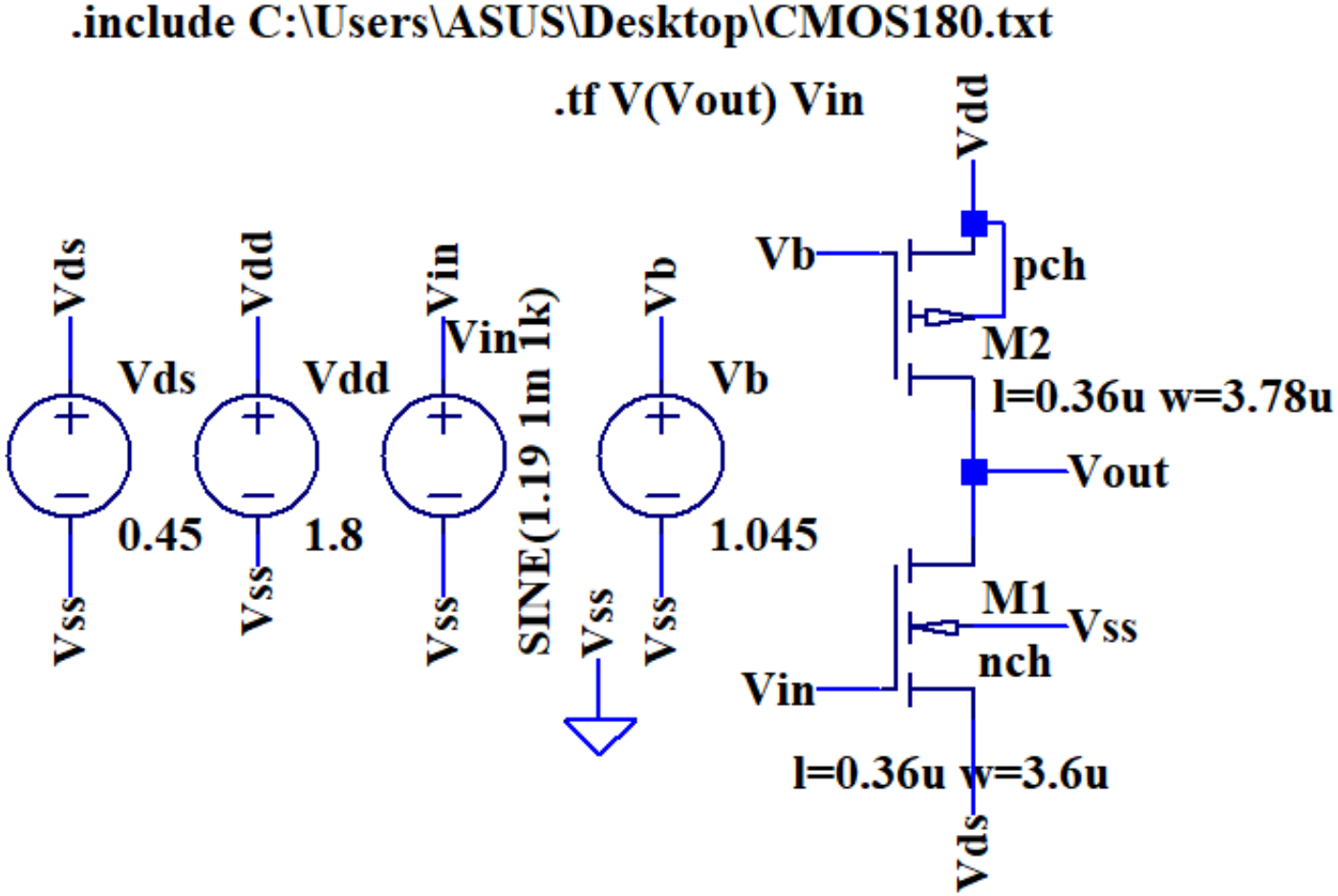
Formula Used

Av=gm.Rout Rout=Ro1 // Ro3 gds=$\frac{1}{ro}$

W=$\frac{id}{id/w}$

- gm=0.43 mS
- gm/id=12 gm/gds=70.92 Id/W=9.896
- Id=35.8 µA gds=6.06 µS W1=3.61 µm
- Ro1=165 KΩ Ro3= 213.125 KΩ
- gds3= 4.69 µS
- $(Id/gds)_3$=7.63
- gm/id=6.315 Id/W=9.133
- W3=3.91 µm

SIMULATION

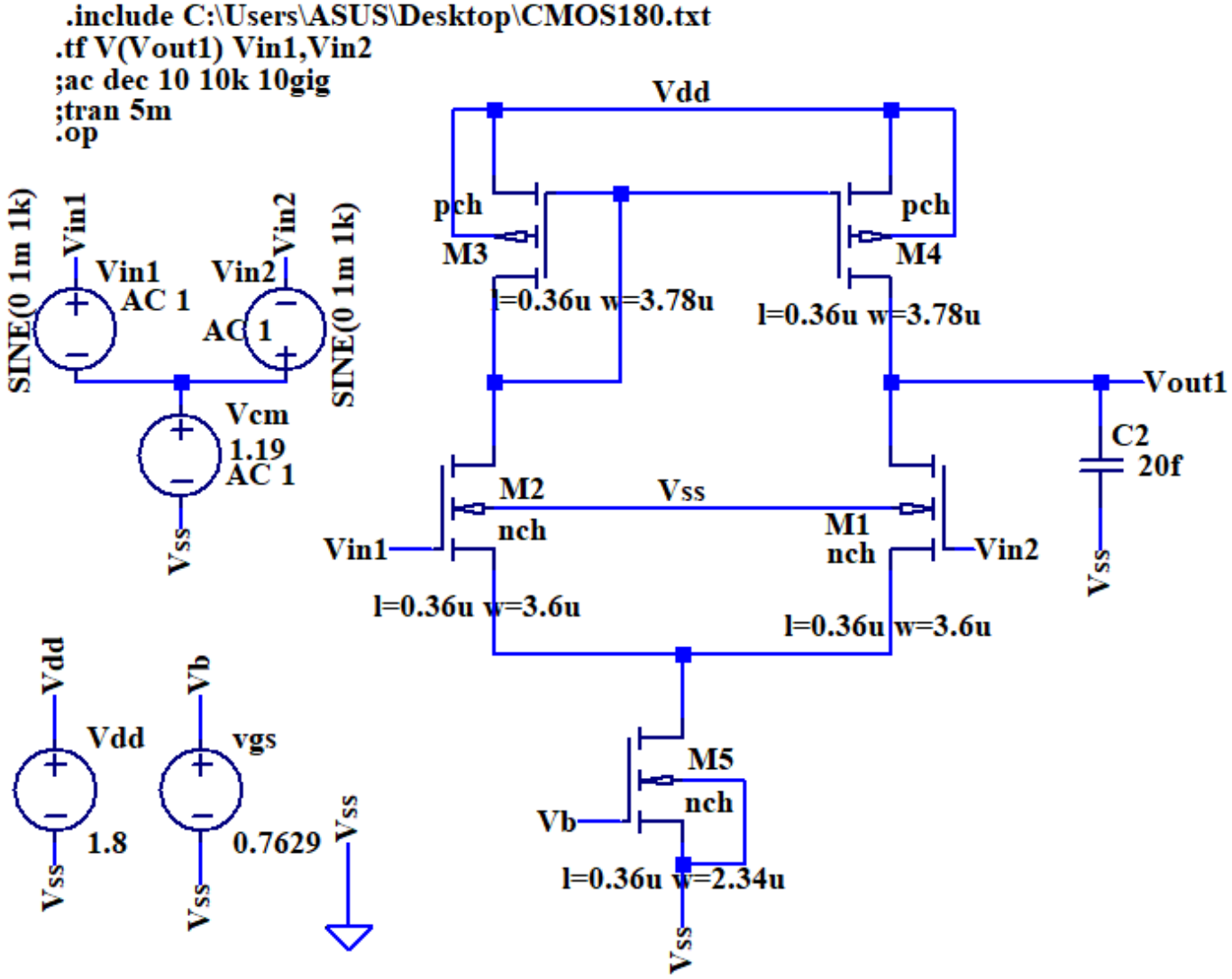

.include C:\Users\ASUS\Desktop\CMOS180.txt
.tf V(Vout) Vin
Vds
Vds
0.45
Vss
Vdd
Vdd
1.8
Vss
Vin
Vin
SINE(1.19 1m 1k)
Vss
Vb
Vb
1.045
Vss
Vdd
Vb
pch
M2
l=0.36u w=3.78u
Vout
M1
Vss
nch
Vin
l=0.36u w=3.6u
Vds

RESULTS

Simulated Value	Specifications
Av= 40.15 v/v	Av=40 v/v
Rout=95.632 KΩ	Rout=93 KΩ
Id= 35.18 µA	Id= 35.8 µA
Vout(dc)=1.07 V	Vout(dc)=0.9 V

OP-AMP (STAGE-1)

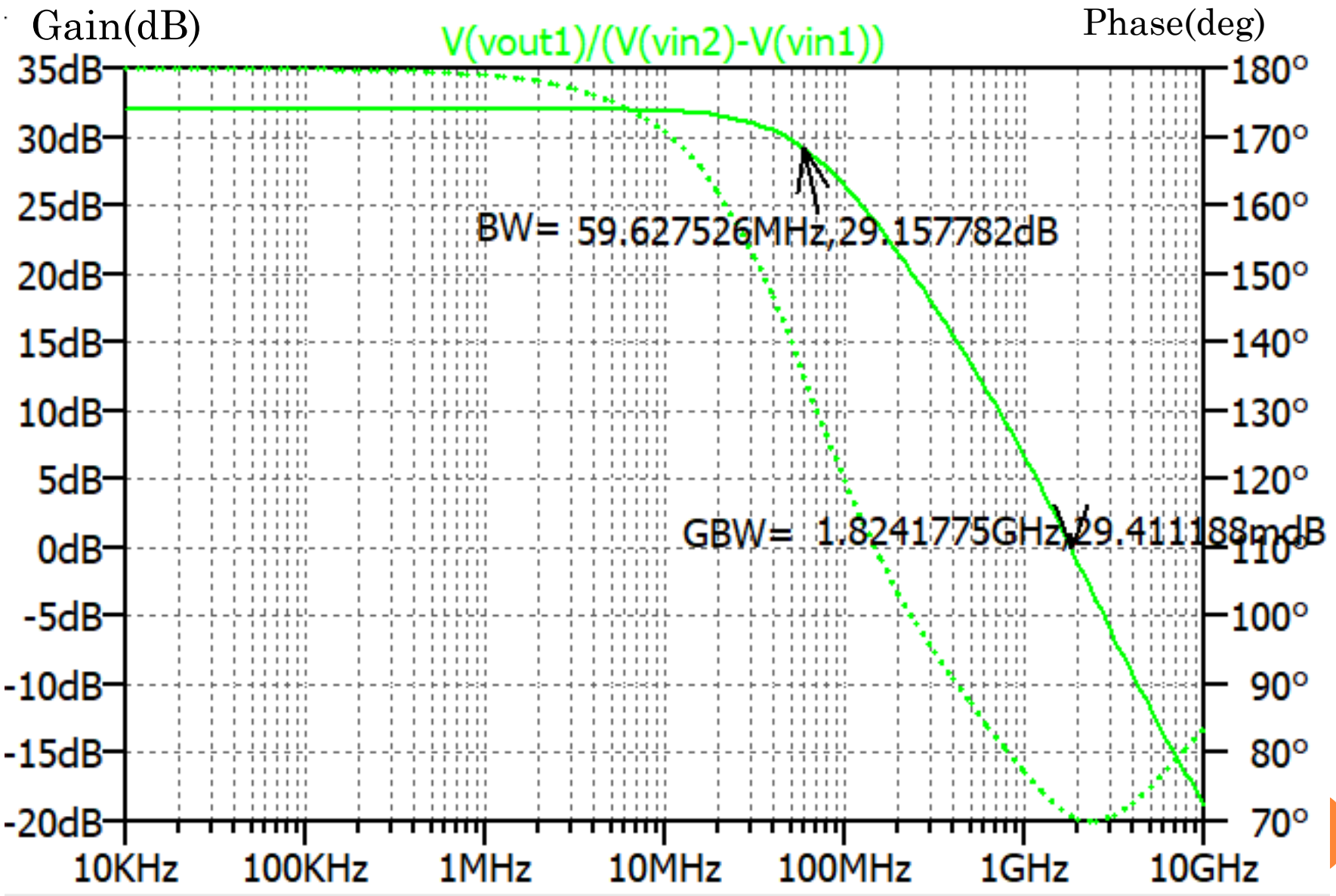
Using Common Source Amplifier



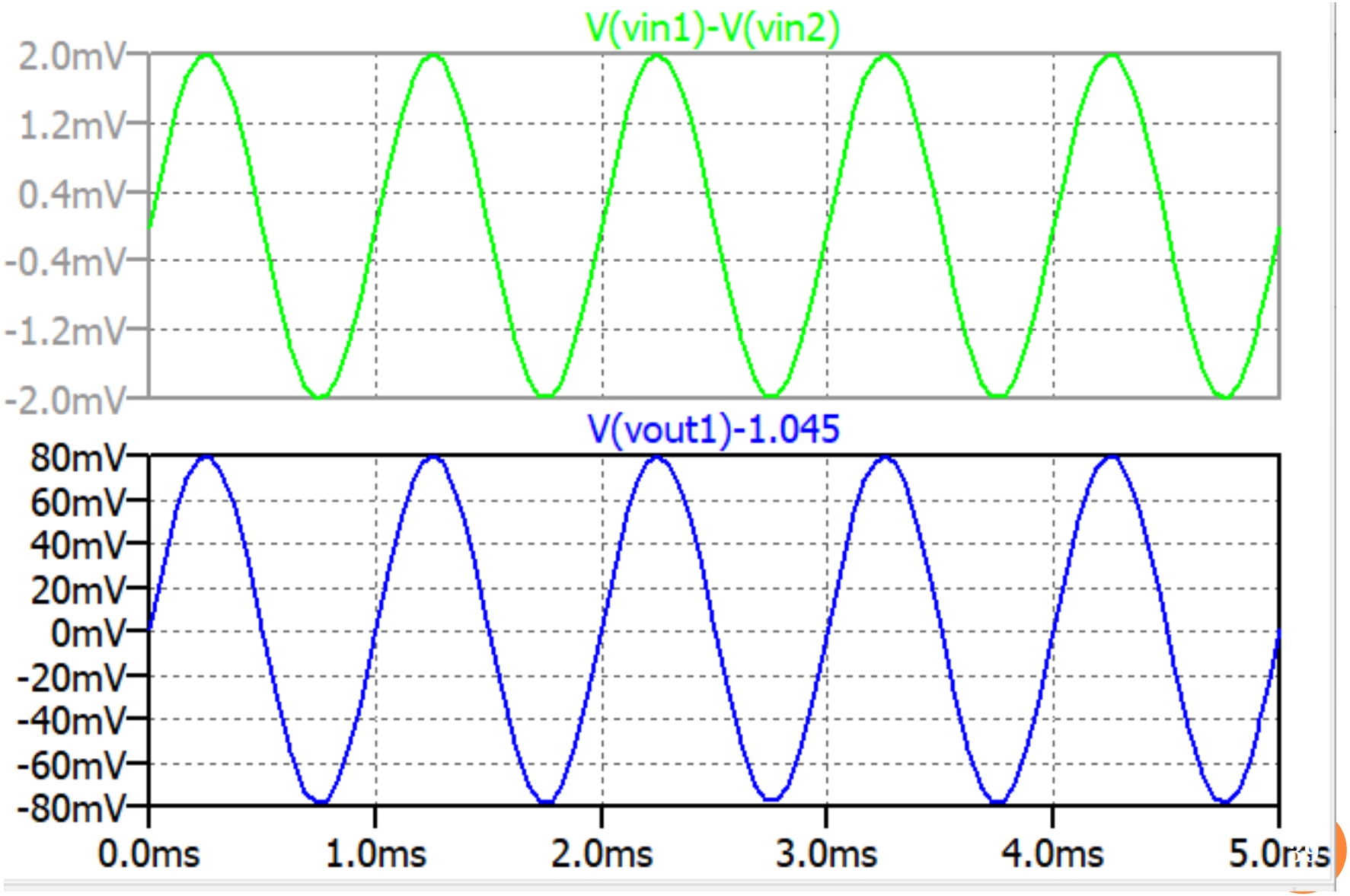
RESULT

Simulated Value	Specifications
Av= 39.8092 v/v	Av=40 v/v
BW=28.66 MHz	BW=25MHz
GBW=1.03 GHz	GBW=1 GHz
Rout=97.259 KΩ	Rout=93 KΩ
Iss= 70.3 µA	Iss= 71.6 µA
Vout(dc)=1.04 V	Vout(dc)=1.15 V

Frequency Analysis



Transient Analysis



Vin1-Vin2(pp)=4 mV Vout1(pp)=158.68 mV Gain=39.67

Common Source amplifier

For Second Stage op-amp

Specs:

Av=28

gm2=8 x 0.432 mS = 3.384 mS

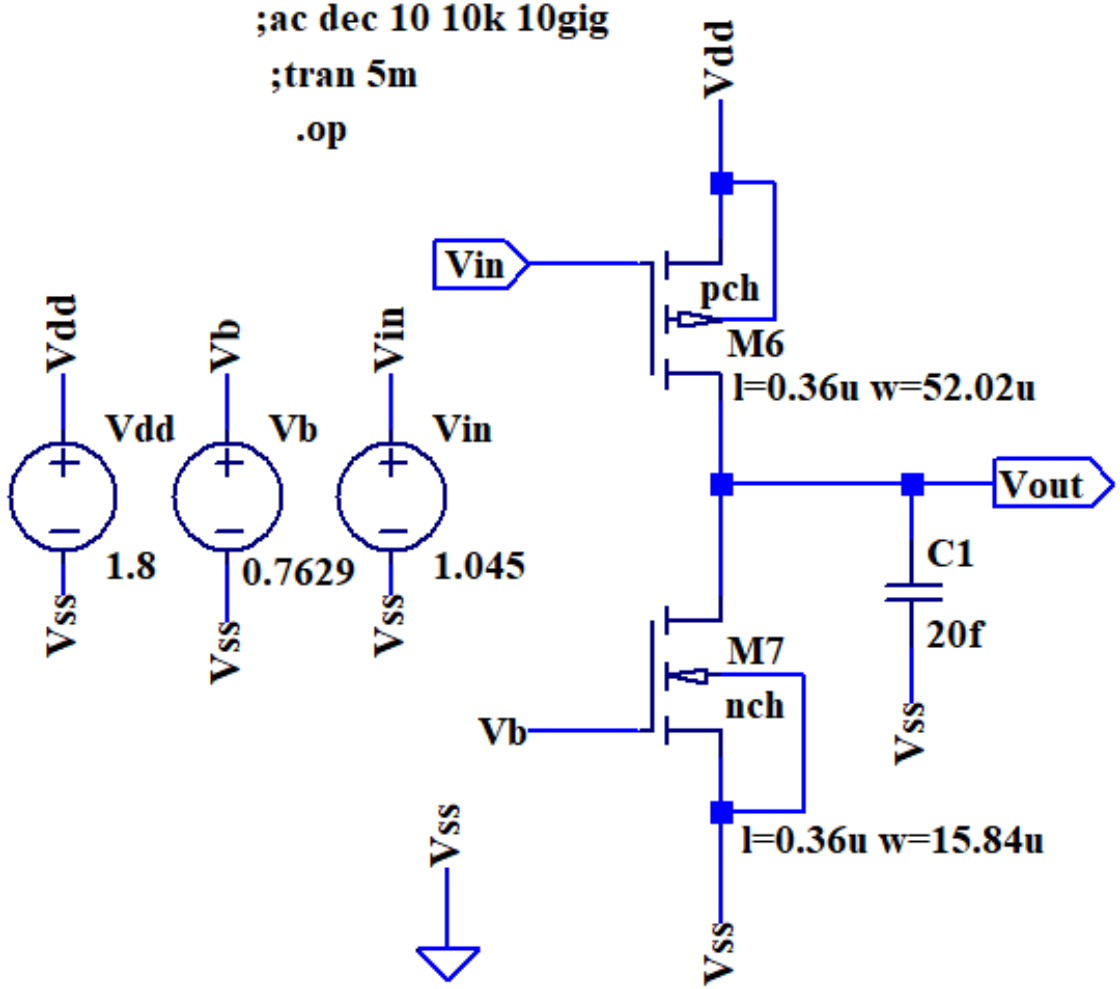
Rout2 = 8KΩ

- Vgs1=780 mV
- gm/id=5.466 id/w=11.9 ….from chart
- gm/gds=46.96 ….from chart
- Id=619 µA
- W6=52µm
- gds6=72.06 µS Ro6= 13.87 KΩ
- Ro7=18.9 KΩ gds7=52.9 µS

- (Id/gds)7=11.7
- gm/id=6.24 id/w=31.05
- W7=19.9 µm **W7=15.84 µm in Simulation**
- Vgs7=0.7629 V

SIMULATION

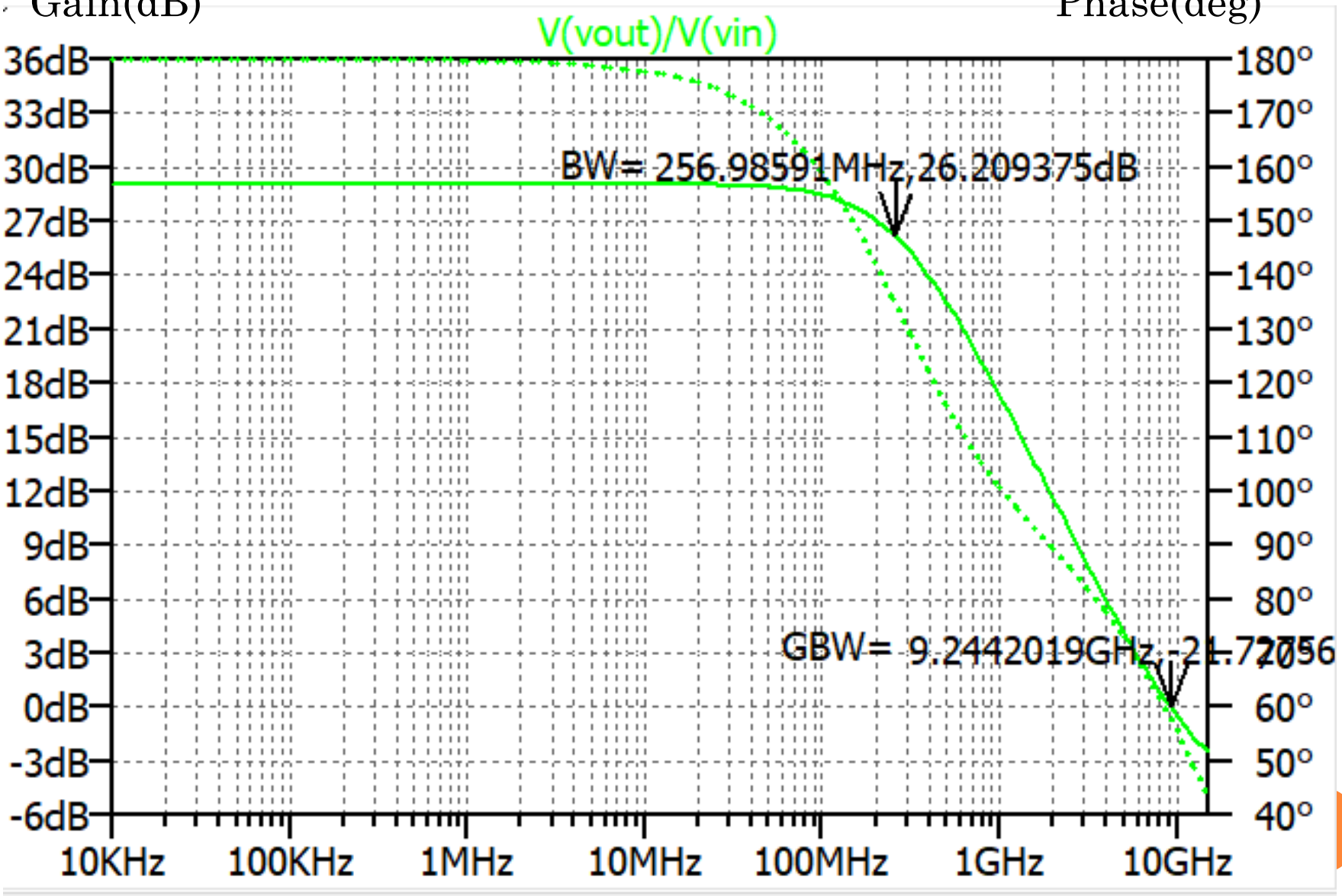
```
.include C:\Users\ASUS\Desktop\CMOS180.txt
.tf V(Vout) Vin
;ac dec 10 10k 10gig
;tran 5m
.op
```



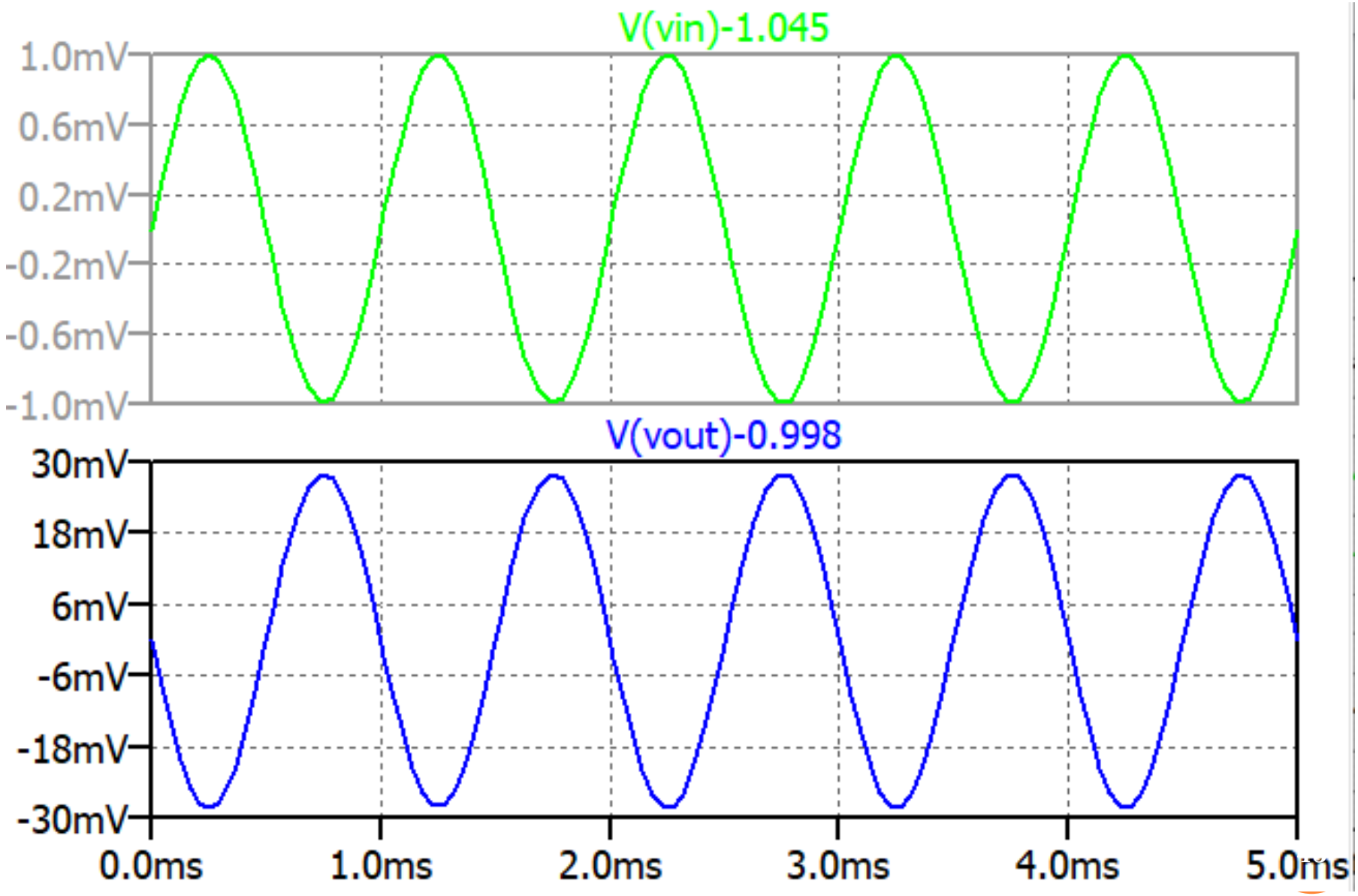
RESULT

Simulated Value	Specifications
Av= 28.34 v/v	Av=28 v/v
BW=256.9 MHz	
GBW=9. 24 GHz	
Rout=9.6 KΩ	Rout=8 KΩ
IB2= 494 µA	IB2= 619 µA
Vout(dc)=0.998 V	Vout(dc)=0.9 V

Frequency Response



Transient Analysis



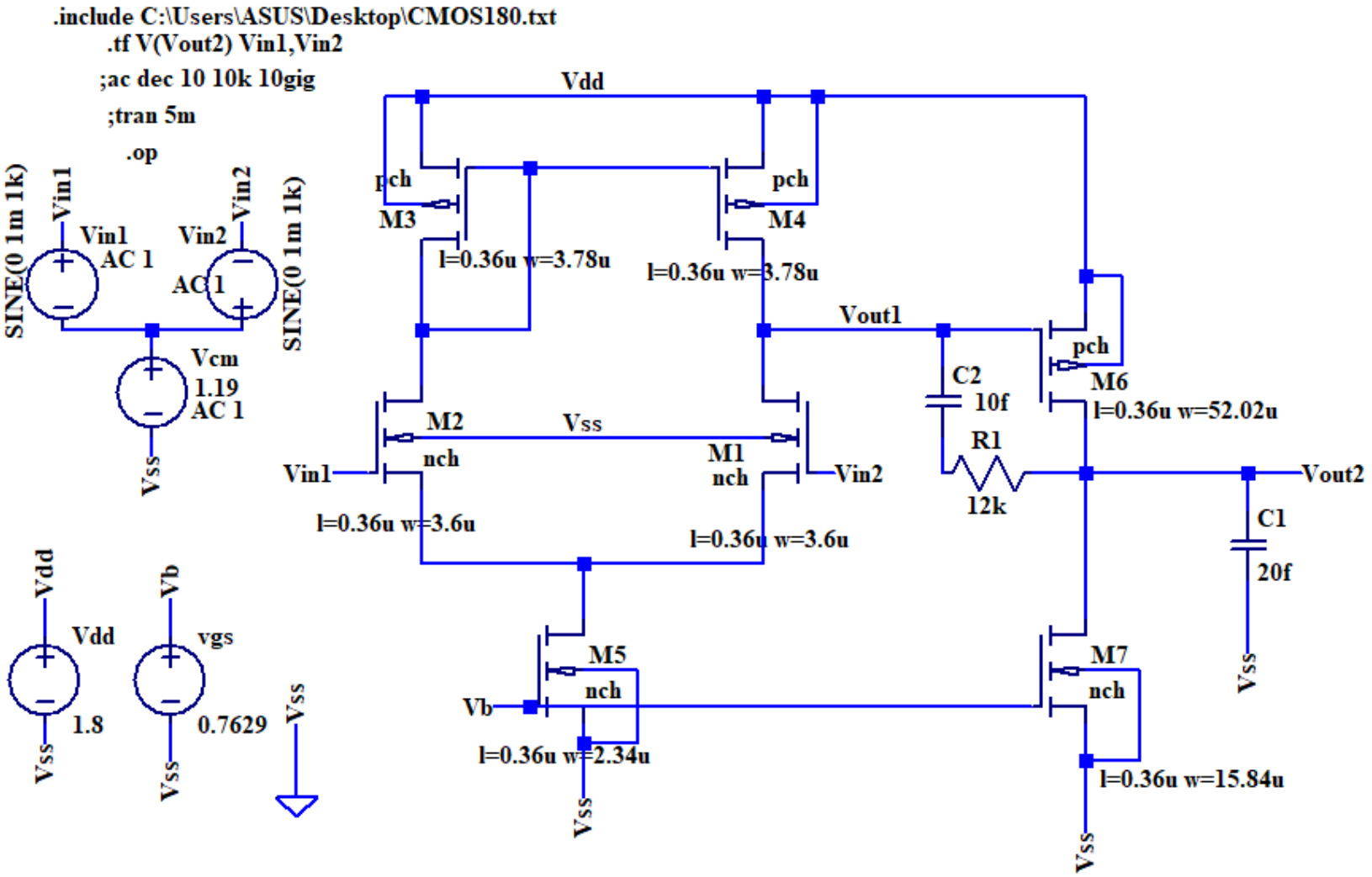
Vin(pp)=2 mV Vout(pp)=56.63 mV Gain=28.315

Project: Designing of two Stage Operational amplifier

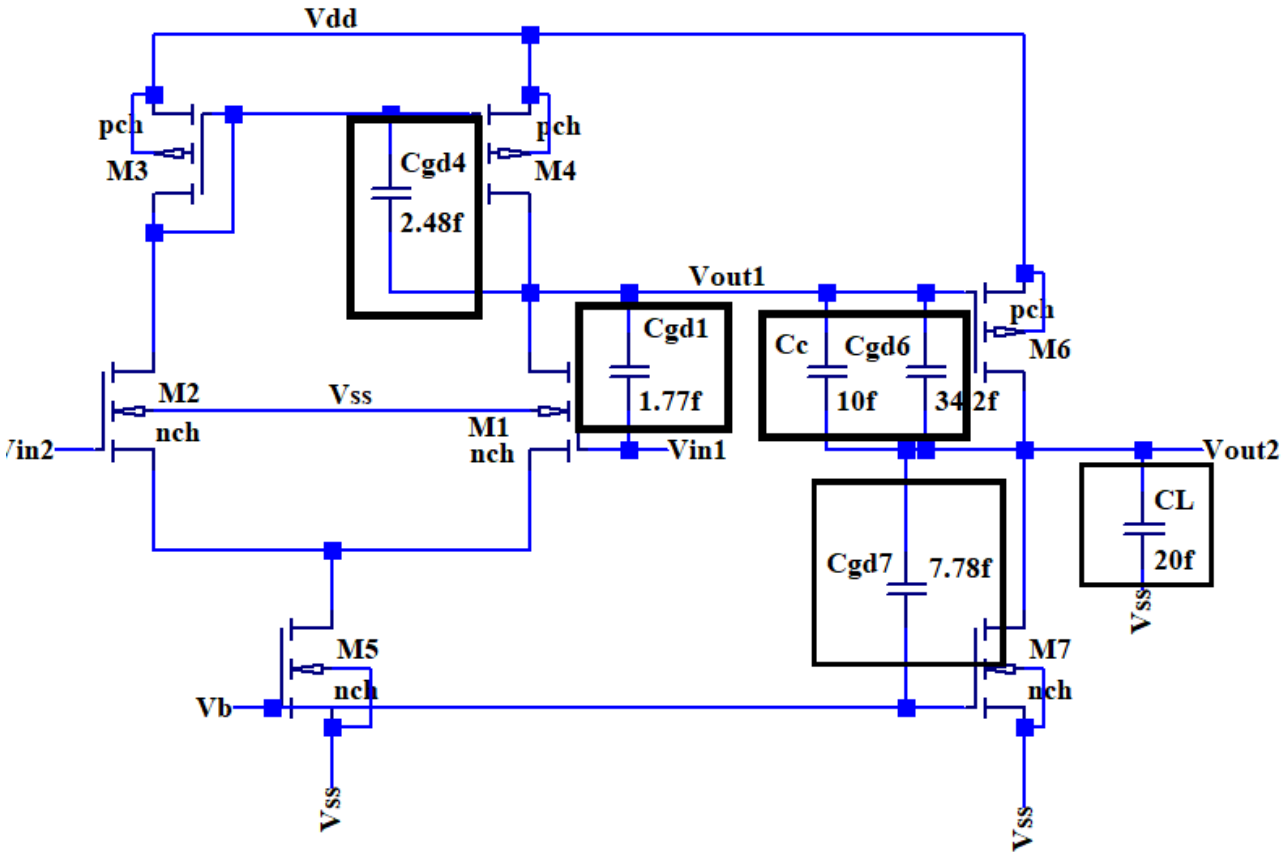
Specification	
Gain(Av)	≥ 1000 (60dB)
GBW	1GHz
Phase Margin	≥50
Load Capacitance	20 fF

PROJECT: TWO STAGE OP-AMP

Combining Stage-1 and Stage-2



CAPACITOR



C1=Capacitance at Node(Vout1)= Cgd4 + Cgd1 + { (Cgd6 + Cc)*(1+Av2)}

C1= 1.3 pF

C2=Capacitance at Node(Vout2)= CL + Cgd7 + { (Cgd6 + Cc)*(1 + $\frac{1}{Av2}$)}

C2=73.52 fF

Pole And Zero

- Dominant Pole
- Fp1 = $\frac{1}{2\pi.Rout1.C1}$
- Fp1= 1.2 MHz where Rout1=97.25 KΩ

- Fp2= Beyond 1GHz

- Sz= $\frac{1}{Cc(\frac{1}{Gm6}-Rz)}$
- Fz= -1.36GHz where Rz=12k, Gm2=2.95mS

Frequency Compensation

- Cc=10 fF (generally Cc=(0.3 – 0.5)*CL)
- Rz=12 KΩ (generally Rz=$^{1}/_{Gm2}$)
- But we have taken 12 KΩ for achieving Phase Margin of 45°.

RESULT

Simulated Value	Specifications
Av= 1139 v/v	Av $\geq$ 1000 v/v
BW=1.12 MHz	BW=1 MHz
GBW=1.02 GHz	**GBW=1 GHz**
Rout=9.68 KΩ	Rout=8 KΩ
Vout(dc)=0.97 V	Vout(dc)=0.9 V
IB1=70.3 µA, IB2= 493.24 µA Total Current=563.54 µA Vdd=1.8 Powe Discipation = 1.01 mW	- - - -
Phase Margin = 45º	Phase Margin = 50º
Gain Margin = 16.5 dB	-
CL=20 fF	CL=20 fF

TABLE

Stage 1	Stage 2
L=0.36µm	L=0.36µm
$W_{1,2}$ = 3.6µm $\frac{W}{L}$ =10	W_6=52.02µm $\frac{W}{L}$ =144.5
$gm_{1,2}$ = 0.419 mS	gm_6 = 2.59 mS
$W_{3,4}$ = 3.78µm $\frac{W}{L}$ =10 .5	W_7= 15.84 µm $\frac{W}{L}$ =44
$gm_{3,4}$ = 0.21 mS	gm_7 = 3.05 mS

SPICE ERROR LOG FILE

Semiconductor Device Operating Points:

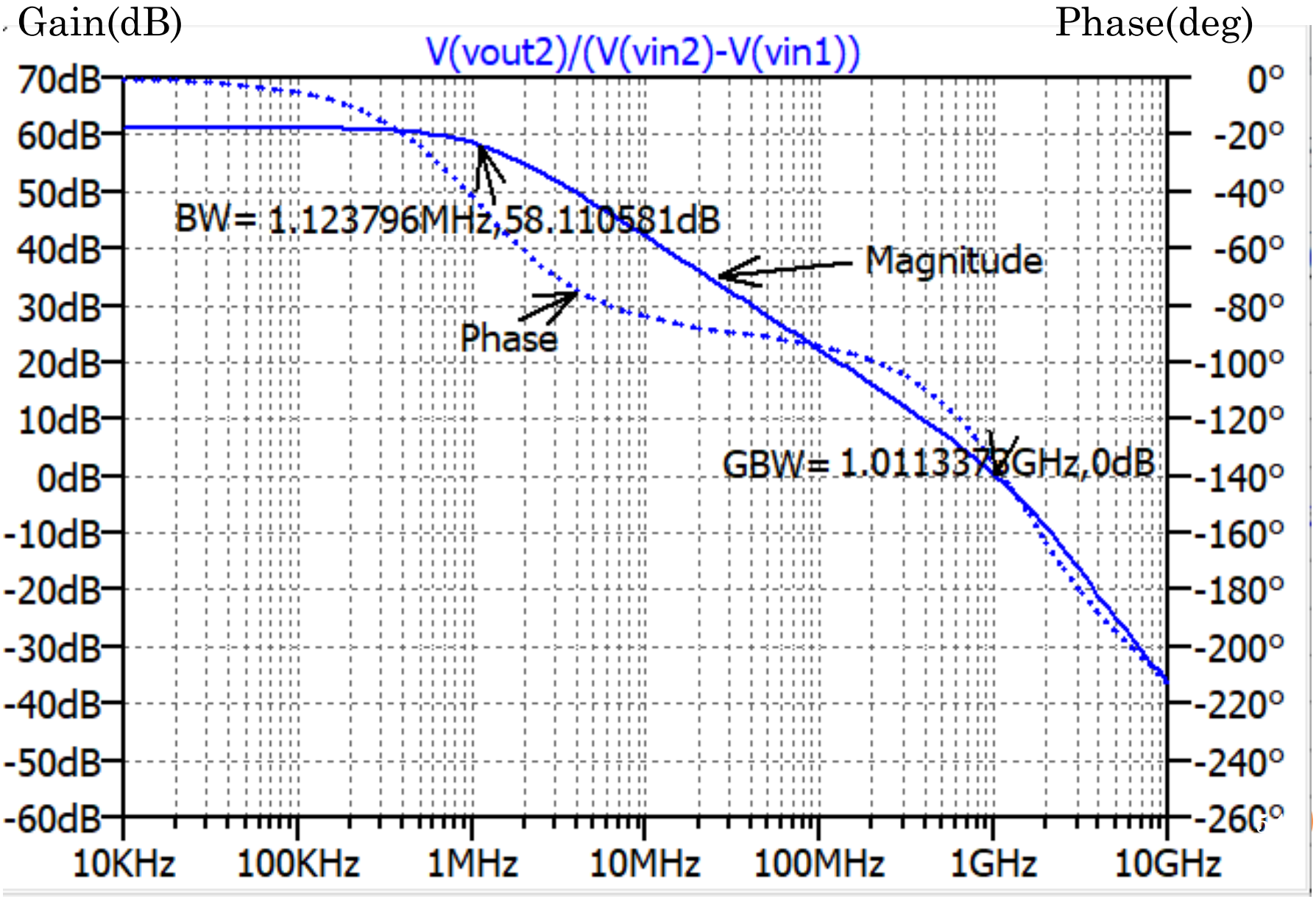
--- BSIM3 MOSFETS ---

Name:	m6	m3	m4	m7	m5	m2	m1
Model:	pch	pch	pch	nch	nch	nch	nch
Id:	-4.93e-04	-3.52e-05	-3.52e-05	4.93e-04	7.03e-05	3.52e-05	3.52e-05
Vgs:	-7.54e-01	-7.54e-01	-7.54e-01	7.63e-01	7.63e-01	7.40e-01	7.40e-01
Vds:	-8.26e-01	-7.54e-01	-7.54e-01	9.74e-01	4.50e-01	5.96e-01	5.96e-01
Vbs:	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	-4.50e-01	-4.50e-01
Vth:	-4.50e-01	-4.48e-01	-4.48e-01	4.58e-01	4.62e-01	5.82e-01	5.82e-01
Vdsat:	-2.55e-01	-2.50e-01	-2.50e-01	2.19e-01	2.15e-01	1.38e-01	1.38e-01
Gm:	2.95e-03	2.11e-04	2.11e-04	3.05e-03	4.40e-04	4.19e-04	4.19e-04
Gds:	6.24e-05	4.69e-06	4.69e-06	4.09e-05	1.09e-05	5.73e-06	5.73e-06
Gmb	9.53e-04	6.66e-05	6.66e-05	7.91e-04	1.13e-04	9.52e-05	9.52e-05
Cbd:	0.00e+00	0.00e+00	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	0.00e+00	0.00e+00
Cgsov:	3.42e-14	2.48e-15	2.48e-15	7.78e-15	1.15e-15	1.77e-15	1.77e-15
Cgdov:	3.42e-14	2.48e-15	2.48e-15	7.78e-15	1.15e-15	1.77e-15	1.77e-15
Cgbov:	2.98e-19	2.98e-19	2.98e-19	3.28e-19	3.28e-19	3.28e-19	3.28e-19
dQgdVgb:	1.78e-13	1.30e-14	1.30e-14	5.26e-14	7.80e-15	1.18e-14	1.18e-14
dQgdVdb:	-3.42e-14	-2.48e-15	-2.48e-15	-7.58e-15	-1.13e-15	-1.72e-15	-1.72e-15
dQgdVsb:	-1.38e-13	-1.01e-14	-1.01e-14	-4.27e-14	-6.32e-15	-9.53e-15	-9.53e-15
dQddVgb:	-3.43e-14	-2.50e-15	-2.50e-15	-7.81e-15	-1.19e-15	-1.78e-15	-1.78e-15
dQddVdb:	3.43e-14	2.49e-15	2.49e-15	7.79e-15	1.18e-15	1.78e-15	1.78e-15
dQddVsb:	1.04e-16	8.68e-18	8.68e-18	2.36e-17	1.14e-17	1.33e-17	1.33e-17
dQbdVgb:	-2.25e-14	-1.67e-15	-1.67e-15	-7.92e-15	-1.17e-15	-1.67e-15	-1.67e-15
dQbdVdb:	-2.52e-17	-2.70e-18	-2.70e-18	1.63e-17	-9.51e-18	7.38e-19	7.38e-19
dQbdVsb:	-1.10e-14	-7.45e-16	-7.45e-16	-3.25e-15	-4.67e-16	-4.71e-16	-4.71e-16

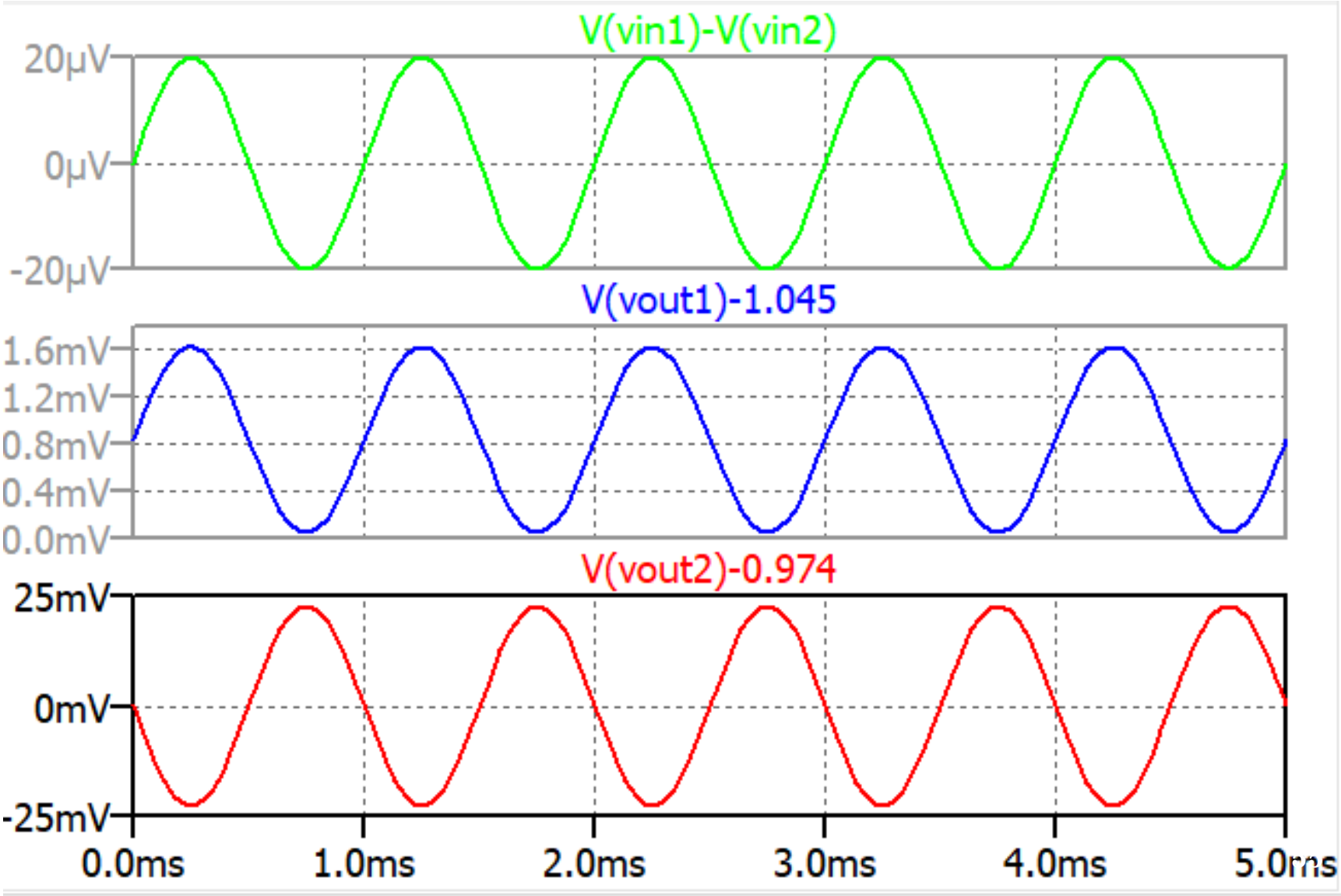
--- Transfer Function ---

Transfer_function:	-1139.14	transfer	
vin1#Input_impedance:	1e+020	impedance	
output_impedance_at_V(vout2):		9688.45	impedance

Frequency Response



Transient Analysis



Vin1-Vin2(pp)=40 µV Vout2(pp)=45.54 mV Gain=1138.5