VLSI LABORATORY EXPERIMENT

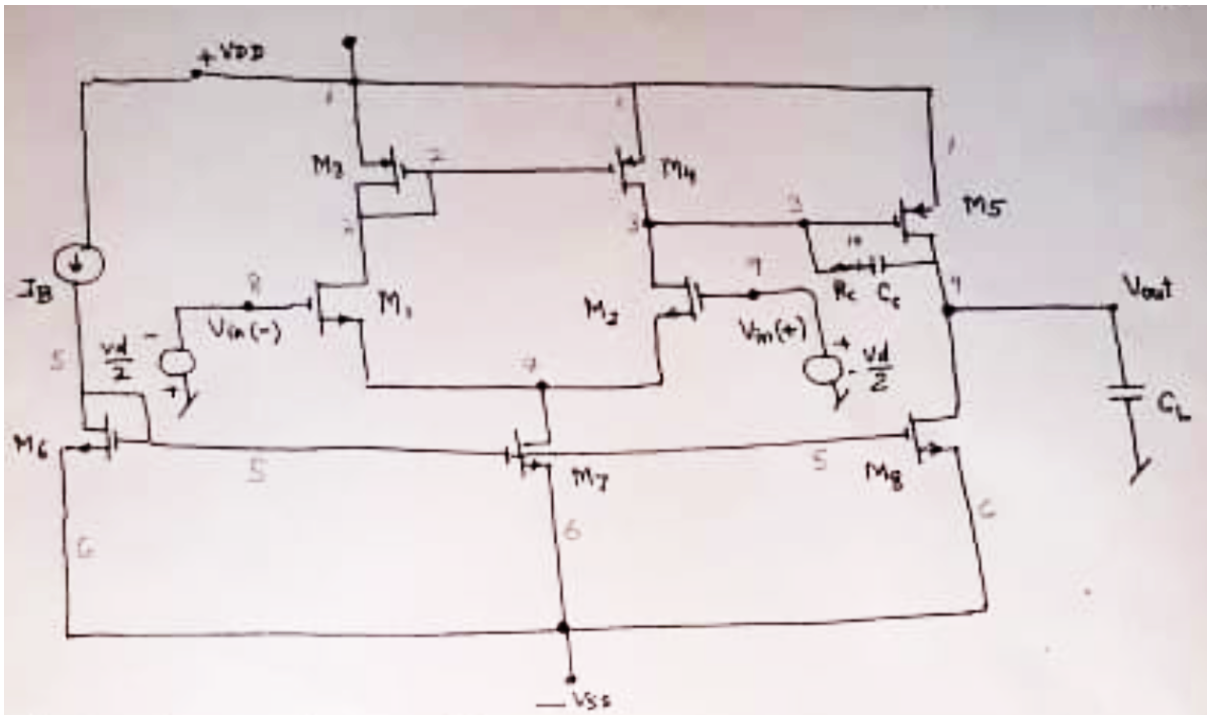
[By Sanuj Kulshrestha, 2017UEC2053, Group 2, ECE 1, Semester 6]

AIM

Simulate a two-stage op-amp and determine

a. **DC characteristics**
b. **Frequency Response**
c. **Slew Rate**
d. **Transient Analysis**

Circuit:



a. DC Characteristics

SPICE CODE:

```
*Two stage Op amp using
.include /Users/sanujkul/Documents/LTspice/Workspace/VLSI/libraries/180nm_model.txt

M1 2 4 5 5 N_180 w=1.25u l=.18u
M2 3 6 5 5 N_180 w=1.25u l=.18u

M3 2 2 1 1 P_180 w=5u l=.18u
M4 3 2 1 1 P_180 w=5u l=.18u
M5 7 3 1 1 P_180 w=5u l=.18u

M6 9 9 10 10 N_180 w=1.25u l=.18u
M7 5 9 10 10 N_180 w=1.25u l=.18u
M8 7 9 10 10 N_180 w=1.25u l=.18u

R0 3 8 2.3k
Cc 8 7 3.5p
Cl 7 0 4p

Vdd 1 0 DC 5v
Vss 10 0 DC -5v

Vid 100 0 DC 1
Rid 100 0 1G
Epos 6 0 100 0 0.5
Eneg 4 0 100 0 -0.5

.DC Vid -0.2 0.2 0.01
```

OBSERVATIONS

Linear Range = -40mV to 40mV

Saturate after Vid = +- 40mV

Cursor 1:

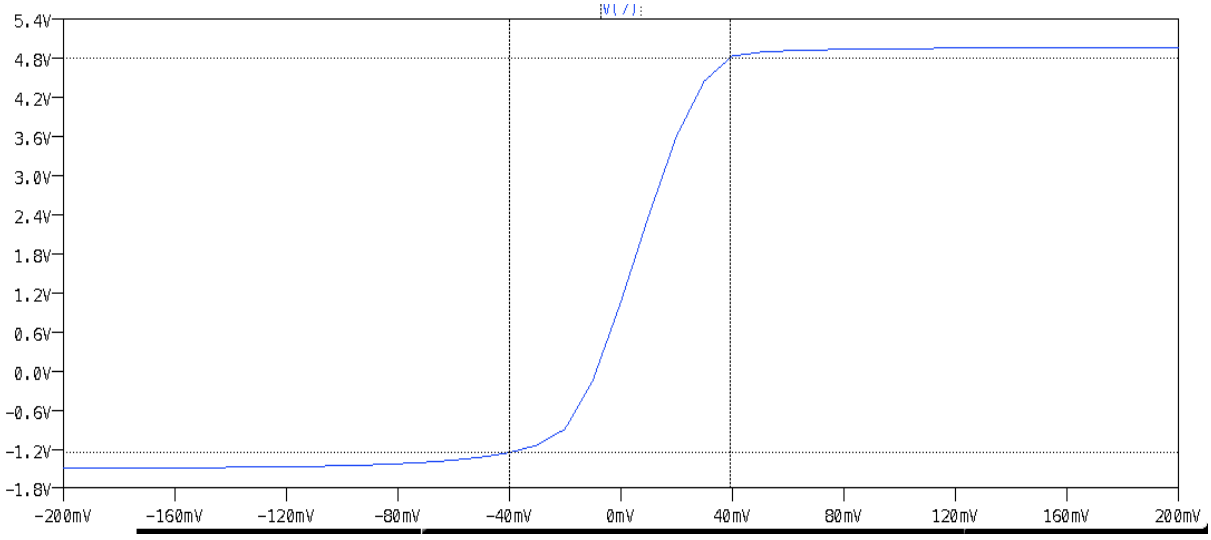
	V(7)		
Horz:	39.305439mV	Vert:	4.8135804V

Cursor 2:

	V(7)		
Horz:	-39.73744mV	Vert:	-1.2498536V

Diff(Cursor 2- Cursor 1):

Horz:	-79.04288mV	Vert:	-6.063434V
Freq:	12.651361Hz	Slope:	76.7107



b. Frequency Response

SPICE CODE:

```
*Two stage Op amp using
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M2 3 6 5 5 N_180 w=1.25u l=.18u

M3 2 2 1 1 P_180 w=5u l=.18u
M4 3 2 1 1 P_180 w=5u l=.18u
M5 7 3 1 1 P_180 w=5u l=.18u

M6 9 9 10 10 N_180 w=1.25u l=.18u
M7 5 9 10 10 N_180 w=1.25u l=.18u
M8 7 9 10 10 N_180 w=1.25u l=.18u

R0 3 8 2.3k
Cc 8 7 3.5p
Cl 7 0 4p

Vdd 1 0 DC 5v
Vss 10 0 DC -5v

Vid 100 0 AC 1m
Rid 100 0 1G
Epos 6 0 100 0 0.5
Eneg 4 0 100 0 -0.5
*AC ANALYSIS
.AC DEC 50 100 1MEG
```
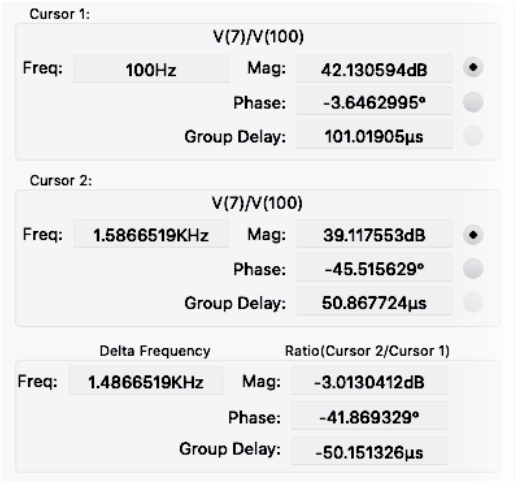
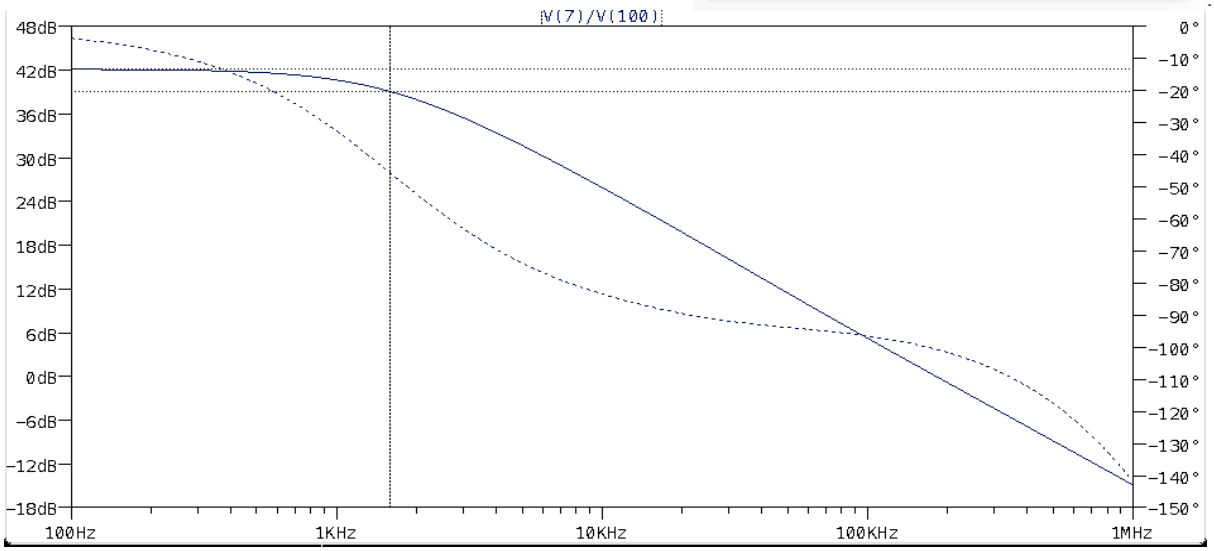

OBSERVATIONS
DC Gain = 42 db = 15.85k
3 db Bandwidth = 1.5886 KHz





c. Slew Rate

SPICE CODE:

```
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M2 3 6 5 5 N_180 w=1.25u l=.18u

M3 2 2 1 1 P_180 w=5u l=.18u
M4 3 2 1 1 P_180 w=5u l=.18u
M5 7 3 1 1 P_180 w=5u l=.18u

M6 9 9 10 10 N_180 w=1.25u l=.18u
M7 5 9 10 10 N_180 w=1.25u l=.18u
M8 7 9 10 10 N_180 w=1.25u l=.18u

R0 3 8 2.3k
Cc 8 7 3.5p
Cl 7 0 4p

Vdd 1 0 DC 5v
Vss 10 0 DC -5v

Vid 100 0 PULSE(0 5V 0.2us 0.1fs 0.1fs 1us 2us)
Rid 100 0 1G
Epos 6 0 100 0 0.5
Eneg 4 0 100 0 -0.5

.TRAN 0 2us
```

OBSERVATIONS

Pulse arrives at 0.2 us.

Output reaches max value at 198.12ns

Slew rate = slope = 2 E07 V/s = 20V/us

Cursor 1:

V(7)

Horz: 198.12183ns Vert: 1.0516611V

Cursor 2:

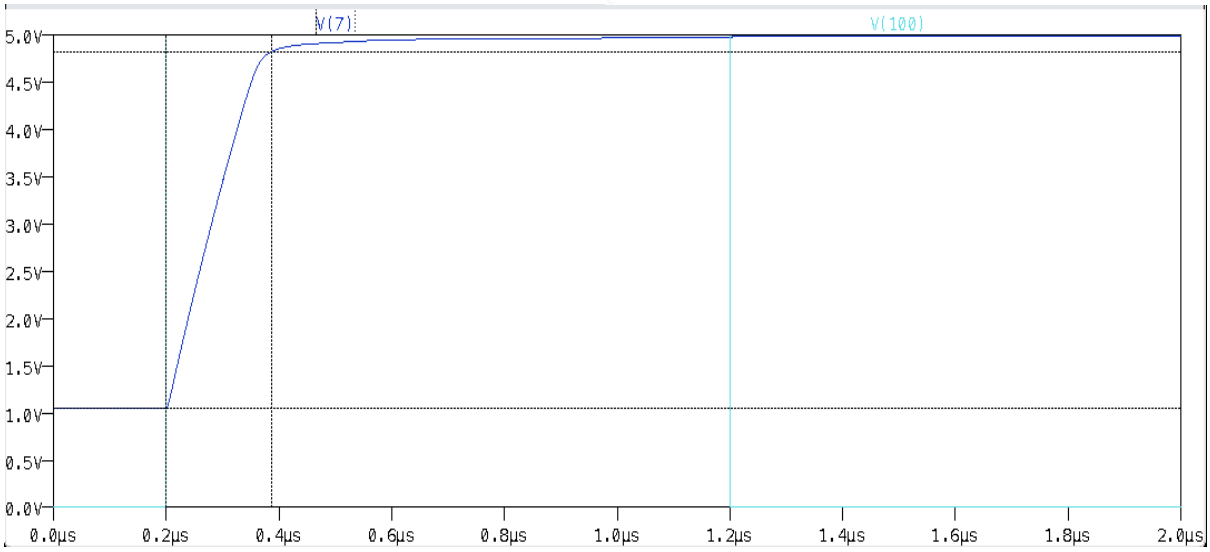
V(7)

Horz: 386.60834ns Vert: 4.8306413V

Diff(Cursor 2- Cursor 1):

Horz: 188.48651ns Vert: 3.7789801V

Freq: 5.3054194MHz Slope: 2.00491e+07

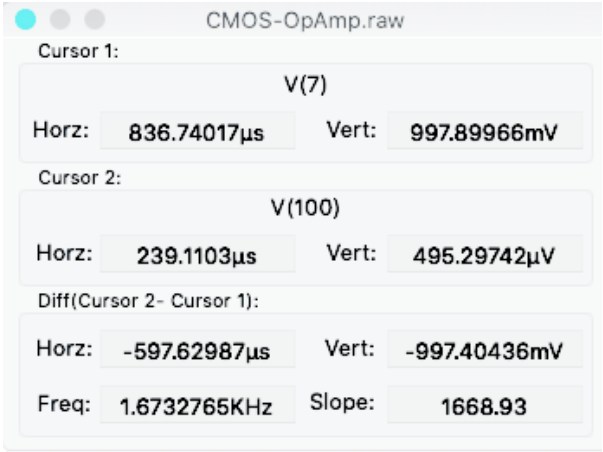


d. Transient Analysis

```
*Two stage Op amp using
.include /Users/sanujkul/Documents/LTspice/Workspace/VLSI/libraries/180nm_model.txt

M1 2 4 5 5 N_180 w=1.25u l=.18u
M2 3 6 5 5 N_180 w=1.25u l=.18u

M3 2 2 1 1 P_180 w=5u l=.18u
M4 3 2 1 1 P_180 w=5u l=.18u
M5 7 3 1 1 P_180 w=5u l=.18u

M6 9 9 10 10 N_180 w=1.25u l=.18u
M7 5 9 10 10 N_180 w=1.25u l=.18u
M8 7 9 10 10 N_180 w=1.25u l=.18u

R0 3 8 2.3k
Cc 8 7 3.5p
Cl 7 0 4p

Vdd 1 0 DC 5v
Vss 10 0 DC -5v

*Vid 100 0 PULSE(0 5V 0.2us 0.1fs 0.1fs 1us 2us)
Vid 100 0 SIN(0 0.5mV 1000 0 0)
Rid 100 0 1G
Epos 6 0 100 0 0.5
Eneg 4 0 100 0 -0.5

.TRAN 0 2ms
```

OBSERVATIONS

100hz sinusoidal signal is given as input because 100 Hz is under 3dB frequency (i.e. 1.588 KHz) that was found in the AC analysis.



Top graph shows OUTPUT Node.
Bottom graph shows input signal.