

# Gm Calculations:

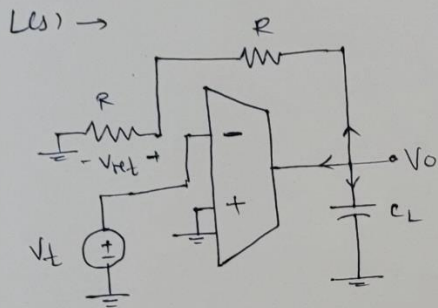
EE-610A Project

Roll No = 22104137 = 4N+1

$V_{DD} = 1.8V$   $C_L = 10pF$  Loop gain = 40dB

-3dB BW  $V_O/V_i = 50MHz$  CMRR (@DC) = 80dB.

1)



KCL At node  $V_O \rightarrow$

$$\frac{V_{ref}}{R} + V_{ref} \cdot (2 \cdot s C_L) + g_m \cdot V_{test} = 0$$

$$V_{ref} \left( \frac{1}{R} + 2s C_L \right) = -g_m V_{test}$$

$$\frac{-V_{ref}}{V_{test}} = \frac{g_m}{\left( \frac{1}{R} + 2s C_L \right)}$$

$$LC(s) = \frac{g_m}{1/R + 2s C_L}$$

$$\therefore LC(s) = \frac{g_m}{1/50k + 2 \cdot s \cdot 10p}$$

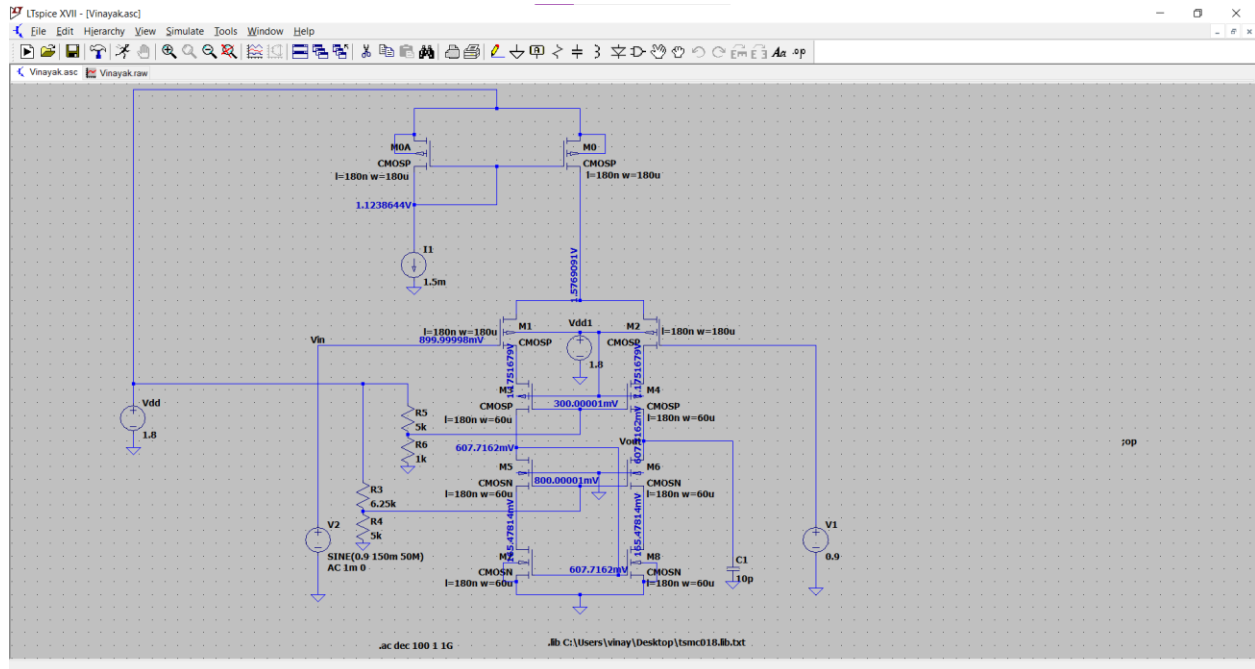
$$\text{At } \omega = 50MHz, |LC(j\omega)| = 1$$

$$1 = \frac{g_m}{\frac{1}{50k} + 2 \times 50 \times 10^6 \times 10 \times 10^{-12} \times 2\pi}$$

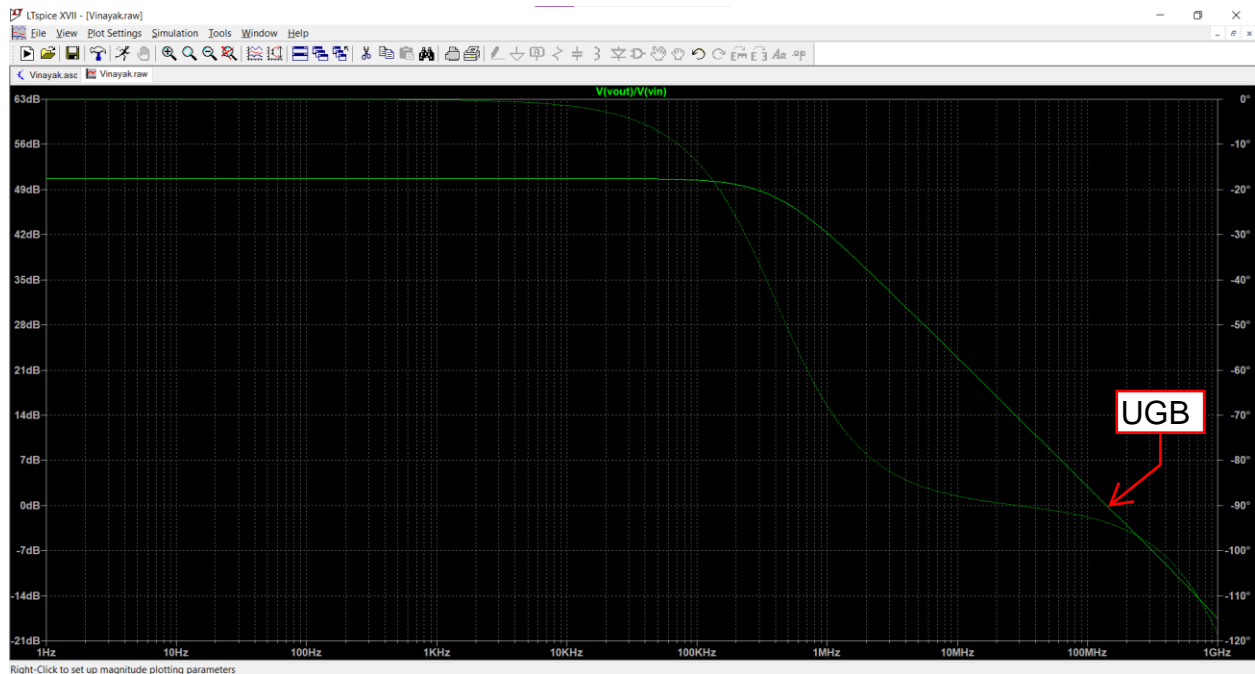
$$g_m \approx 2 \times 2\pi \times 50 \times 10^6 \times 10 \times 10^{-12}$$

$$g_m = 6.28 mS$$

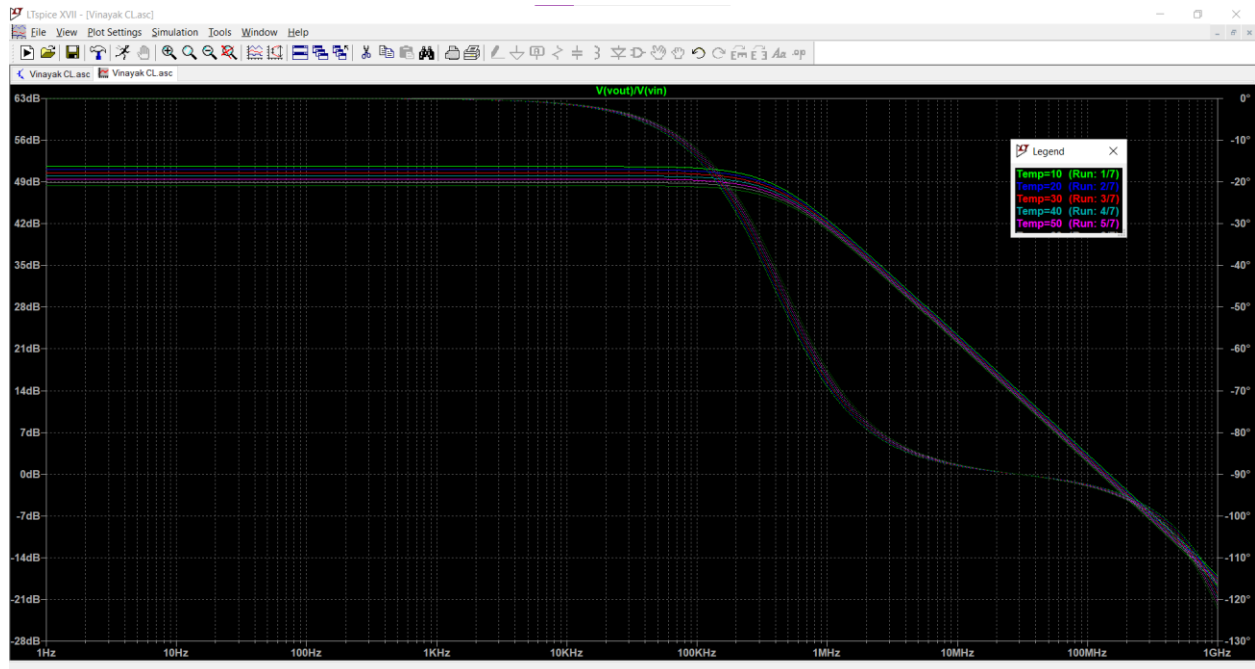
## 1. Open loop schematic diagram:



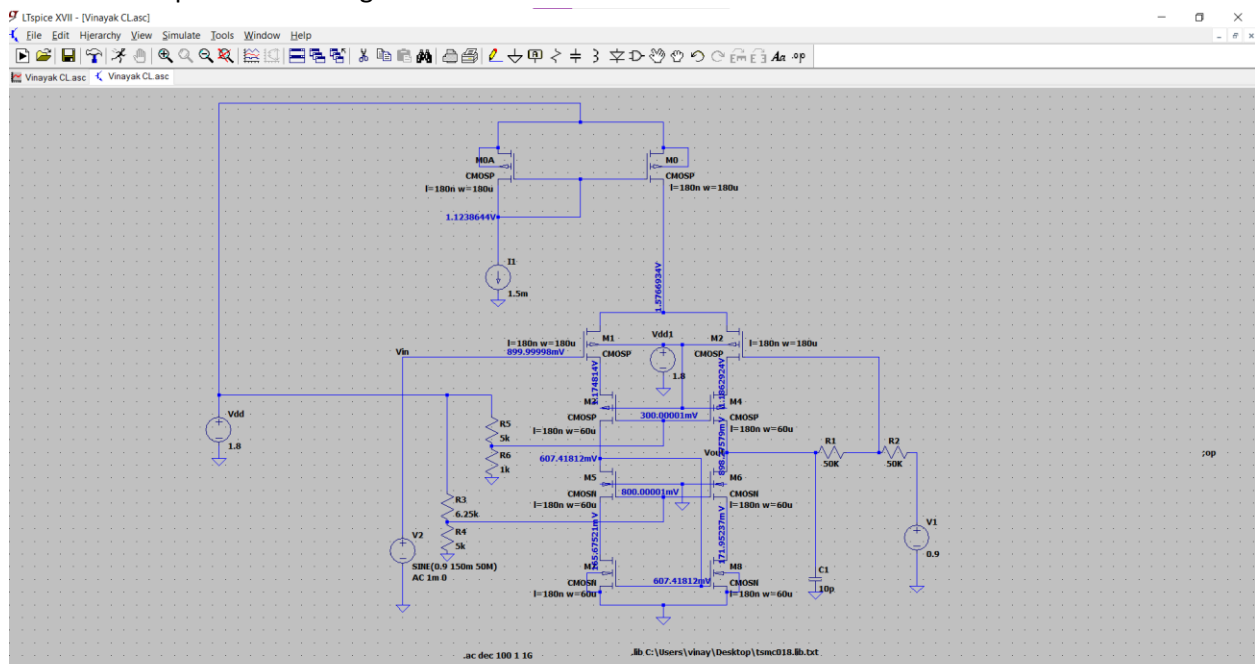
## 2. Open Loop Bode plot:



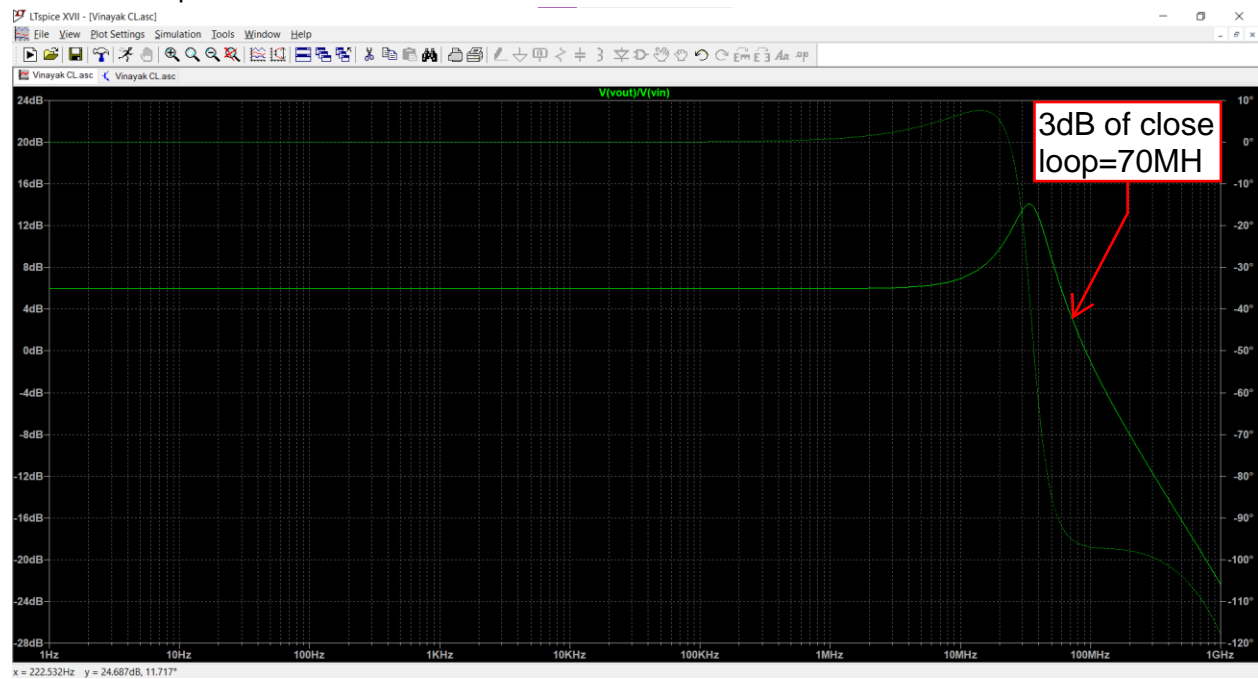
### 3. Open Loop Bode Plot Variation for temperature sweep of 0°C to 70°C:



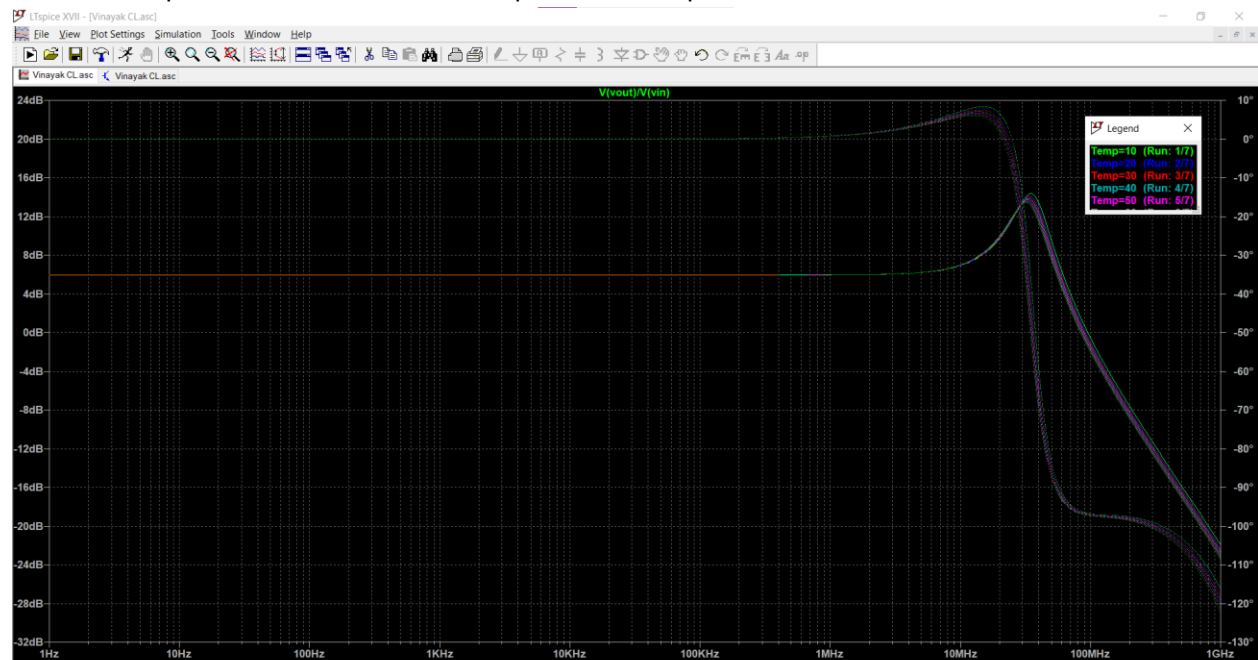
### 4. Closed Loop schematic diagram:



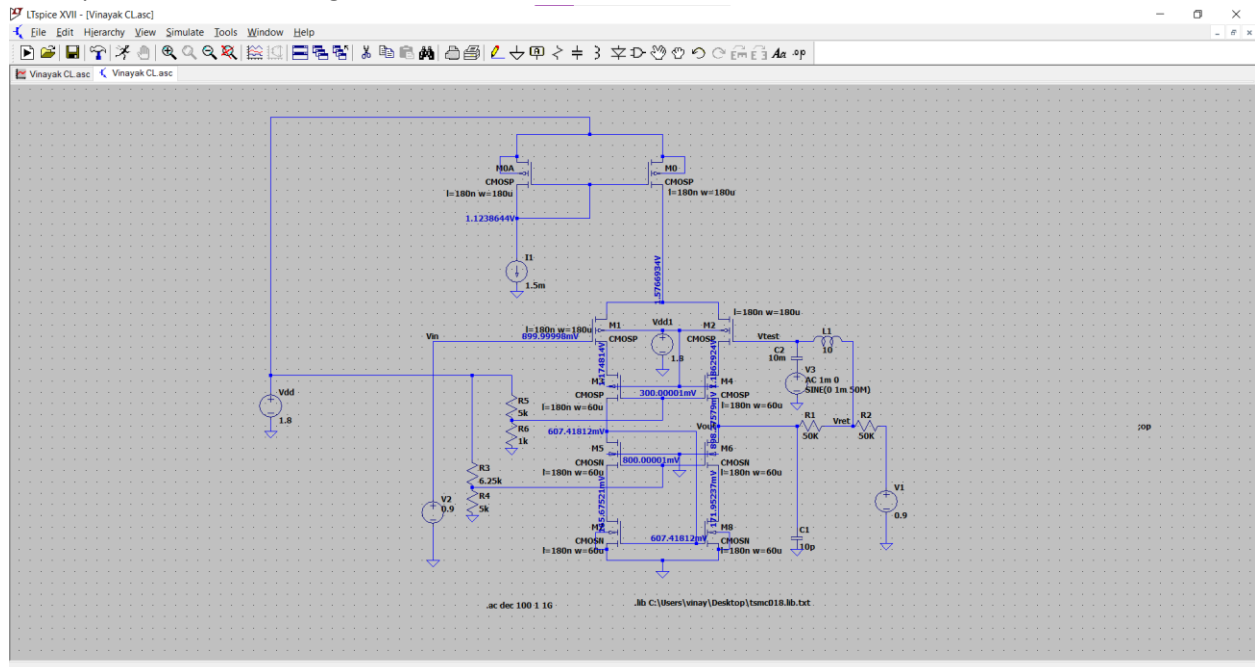
## 5. Closed Loop Bode Plot:



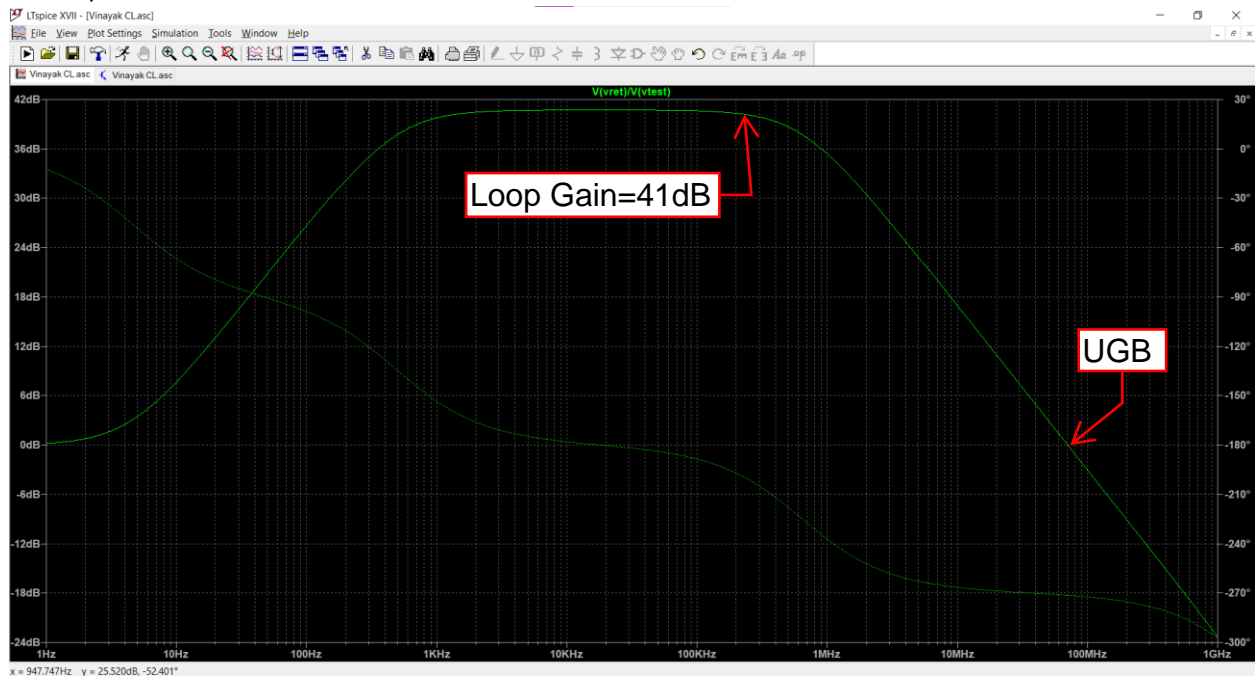
## 6. Closed Loop Bode Plot Variation for temperature sweep of 0°C to 70°C:



## 7. Loop Gain schematic diagram:



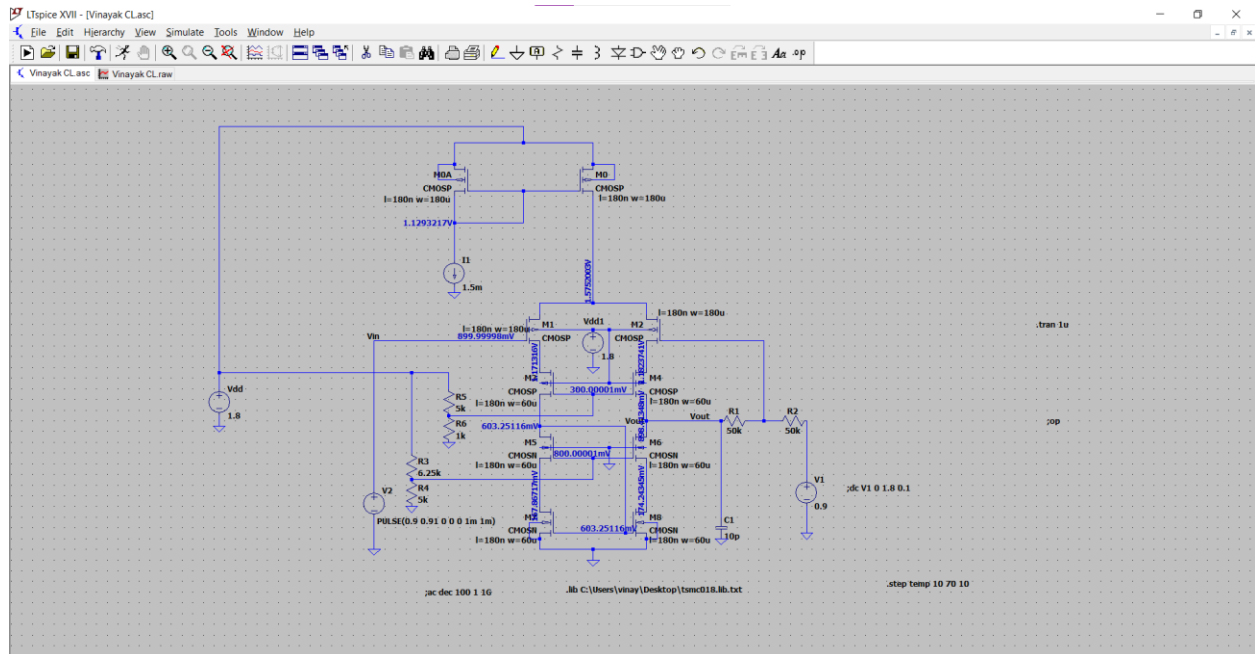
## 8. Loop Gain Bode Plot:



## 9. Loop Gain Bode Plot Variation for temperature sweep of 0°C to 70°C:

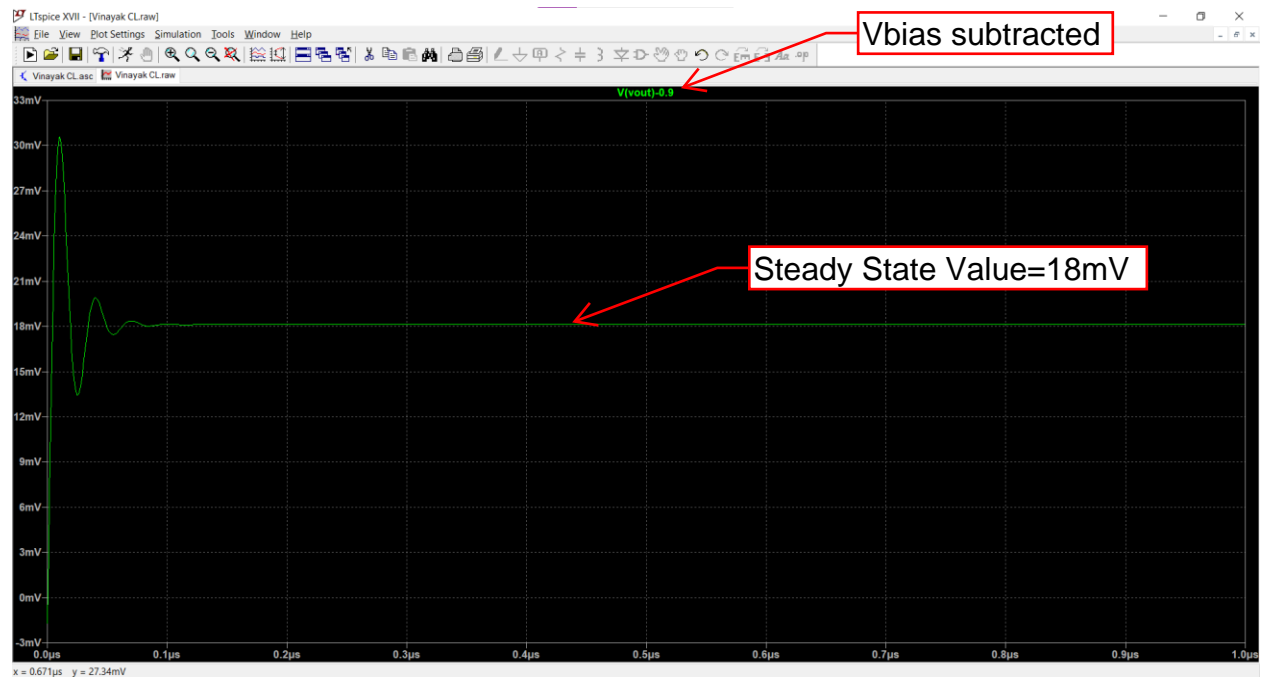


## 10. Schematic for Transient analysis for step input of 0.01V:





11. Transient response for step input of 0.01V:



12. Transient analysis for step input of 0.01V for temperature sweep of 0°C to 70°C:



# Steady State Error Calculation:

Steady state error calculation →

$$\frac{V_o}{V_i} = \frac{1}{H} \left( \frac{G_H}{1+G_H} \right)$$

$$H = \frac{1}{2}$$

$$\therefore \frac{V_o}{V_i} = (2) \left( \frac{g_m R}{1+g_m R} \right) = 2 \times \left( \frac{6.28 \text{ m} \times 50 \text{ k}}{1+6.28 \text{ m} \times 50 \text{ k}} \right)$$

$$V_o = 2 \times \frac{6.28 \times 50}{1+6.28 \times 50} \times 0.01 = 19.93 \text{ mV}$$

$$N_o \text{ Total} = V_o + N_o = 0.9 + 19.93 \text{ mV} = 0.919 \text{ V}$$

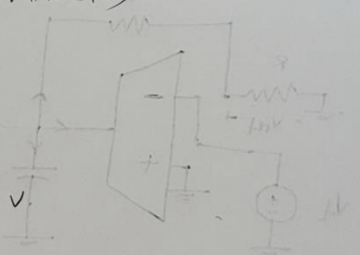
Error →

From Transient response for step inputs

$$N_o = 18 \text{ mV}$$

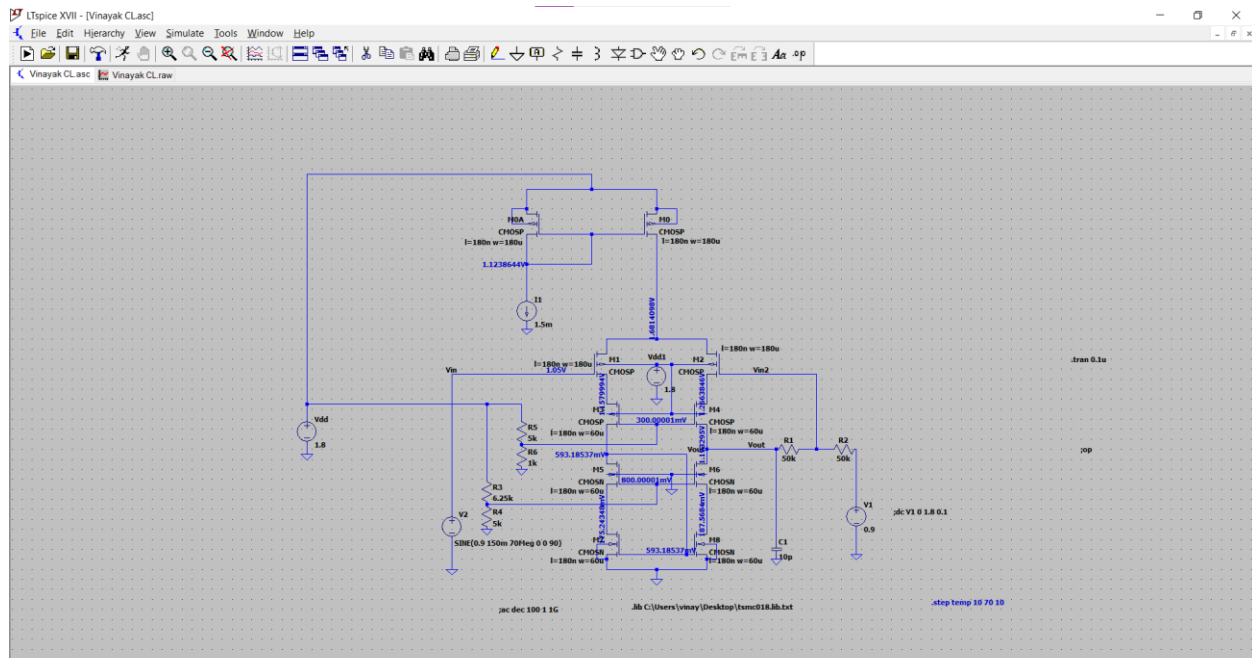
$$\therefore \text{S.S.E} = 19.93 \text{ mV} - 18 \text{ mV}$$

$$\text{S.S.E} = 1.93 \text{ mV}$$

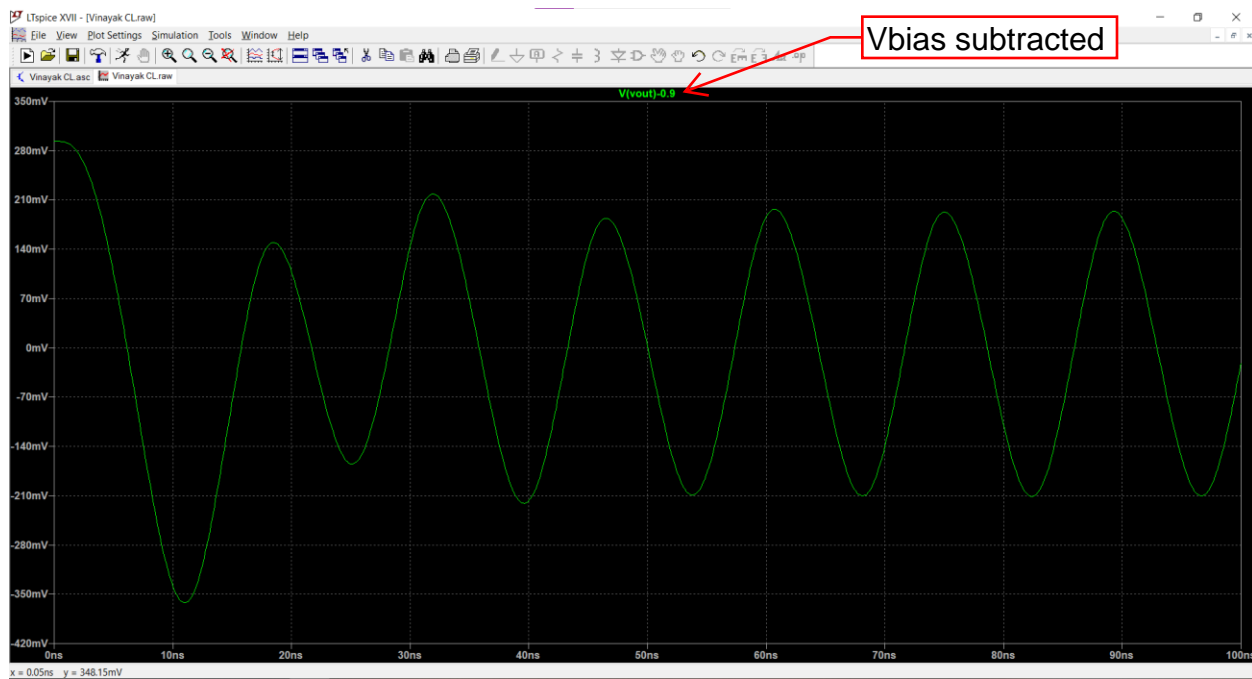




13. Schematic for Transient for Sinusoidal input of  $(150\text{mV})\cos(W_{3\text{dB}}*t)$ ,  $W_{3\text{dB}}=2\pi*70\text{MHz}=439.82$  Mrad/sec:



14. Transient response for Sinusoidal input of  $(150\text{mV})\cos(W_{3\text{dB}}*t)$ ,  $W_{3\text{dB}}=2\pi*70\text{MHz}=439.82$  Mrad/sec:

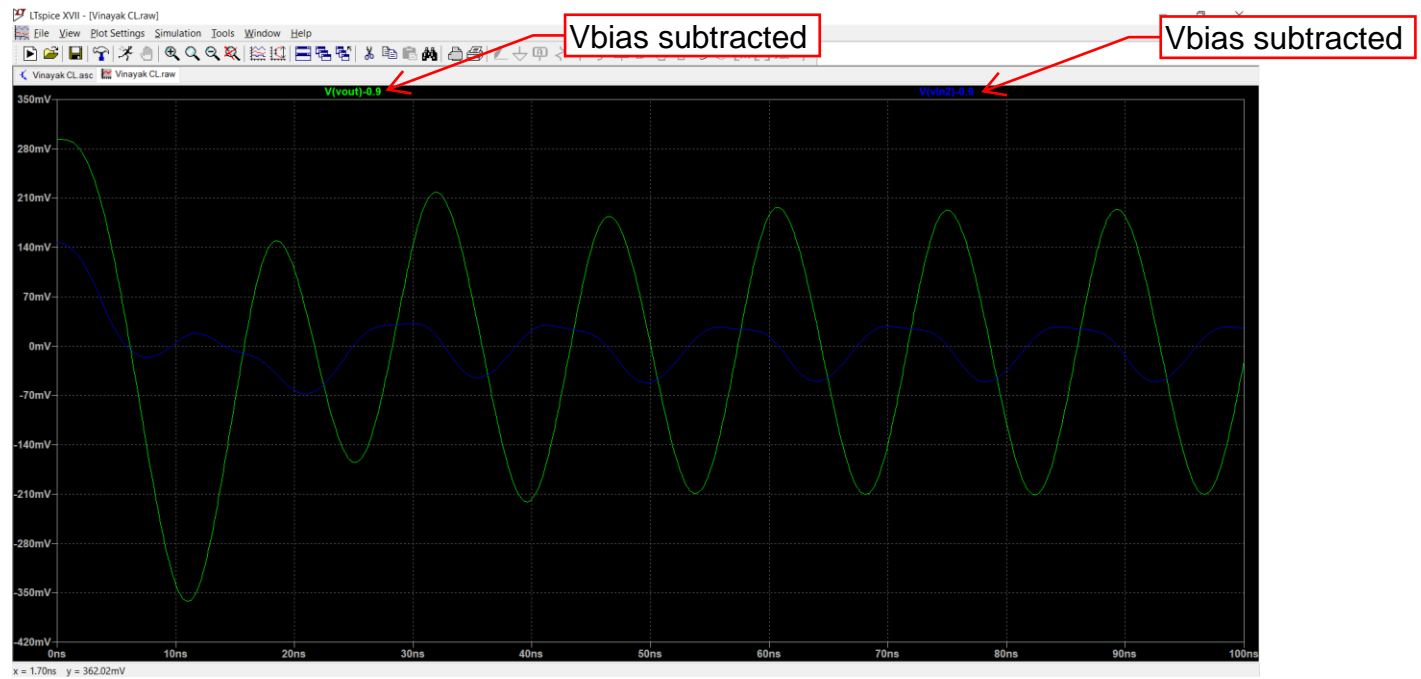


The screenshot shows the LTspice software interface with a circuit simulation. The circuit is a differential amplifier with a current mirror load. The components include:

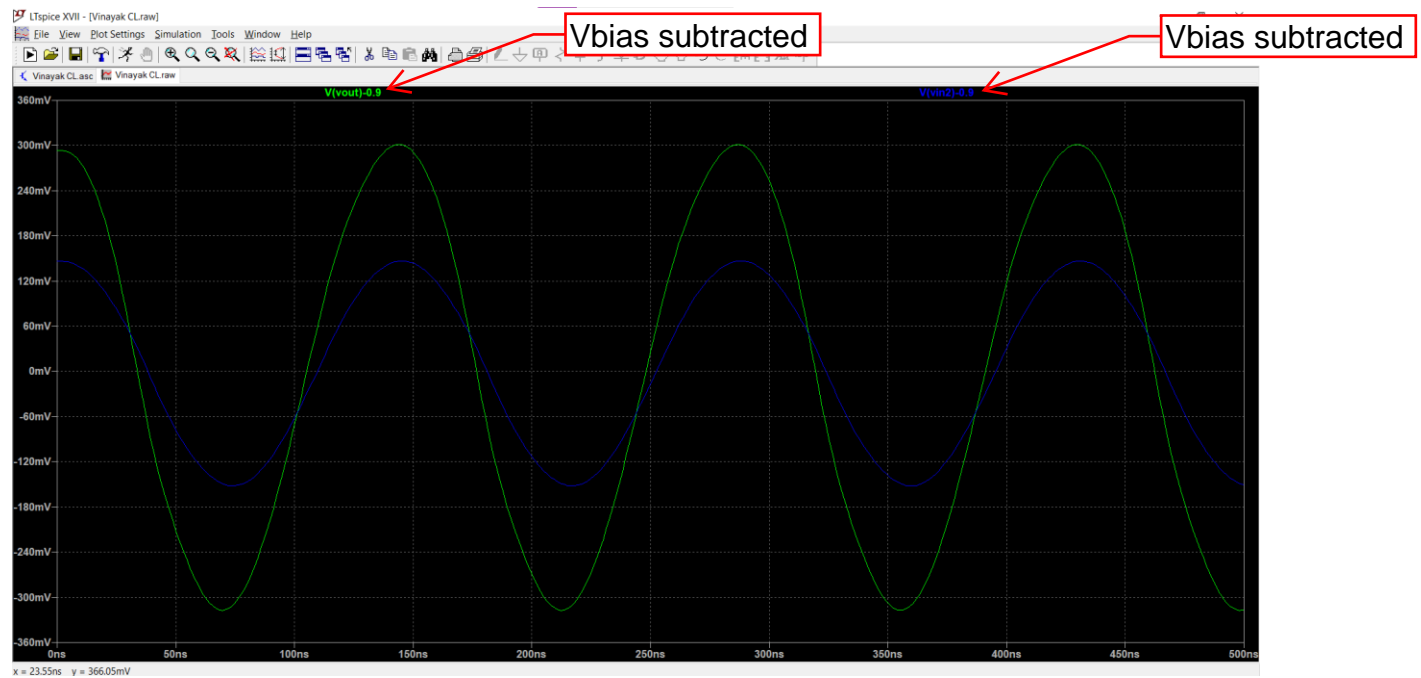
- Current Source:** A 1.5mA current source labeled "1.5mA" connected to the gates of two NMOS transistors (M1 and M2).
- DC Source:** A 1.8V DC source labeled "Vdd" connected to the drains of M1 and M2.
- Transistors:** Two NMOS transistors (M1 and M2) with parameters:  $I=180n$ ,  $w=180u$ . They are connected in a differential pair configuration.
- Resistors:** A 5k resistor (R5) connected to the gates of M1 and M2. A 1k resistor (R6) connected to the gates of M1 and M2. A 6.25k resistor (R3) connected to the gates of M1 and M2. A 50k resistor (R1) connected to the drains of M1 and M2. A 50k resistor (R2) connected to the drains of M1 and M2.
- Capacitors:** A 10pF capacitor (C1) connected to the output of the differential pair.
- Simulation Settings:** The simulation is set to a transient analysis from 0 to 10ns. The output voltage is shown as a sine wave.

The screenshot shows the TSPICE XVII simulation interface. The plot title is  $V(vout)-0.9$ , which is highlighted by a red box and labeled "Vbias subtracted". The plot shows a periodic waveform oscillating between approximately 300mV and -360mV. The x-axis represents time in nanoseconds (ns), ranging from 0ns to 500ns. The y-axis represents voltage in millivolts (mV), ranging from -360mV to 360mV. The waveform is a periodic signal, likely a sine wave, with a period of approximately 150ns.

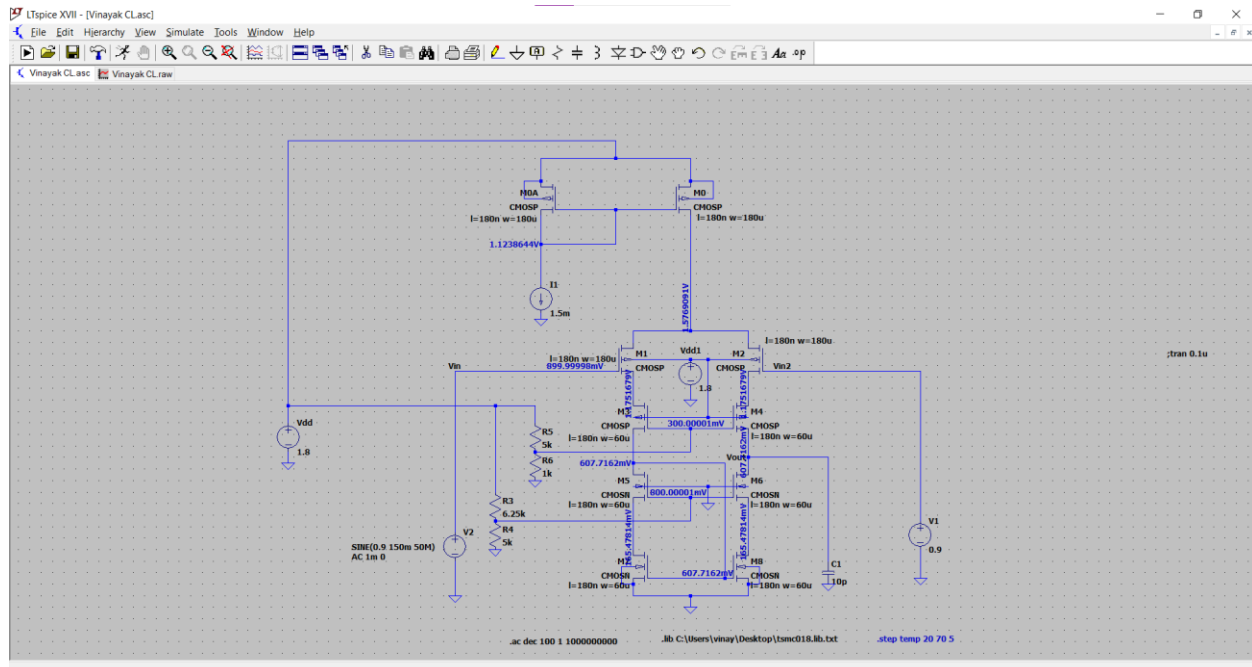
17. Difference between input voltages for Sinusoidal input of  $(150\text{mV})\cos(W_{3\text{dB}}*t)$ :



18. Difference between input voltages for Sinusoidal input of  $(150\text{mV})\cos(W_{3\text{dB}}/10*t)$ :



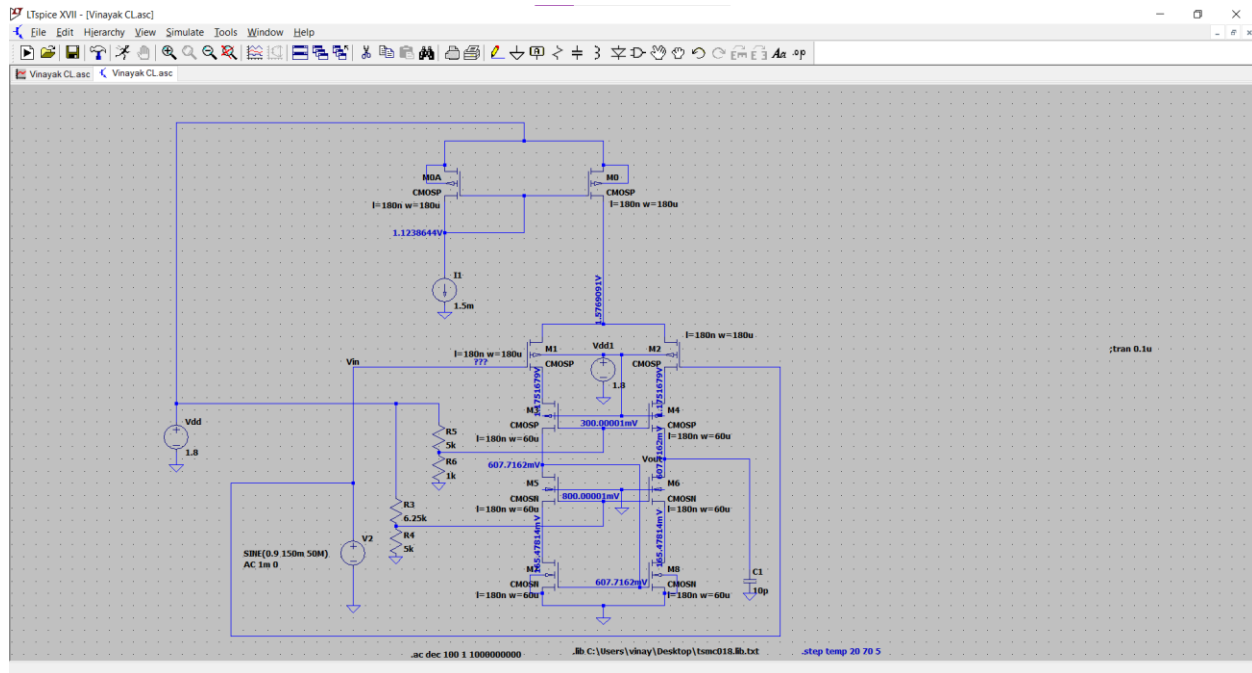
## 19. Schematic for differential gain:



## 20. Bode Plot for differential gain:



## 21. Schematic for common mode gain:



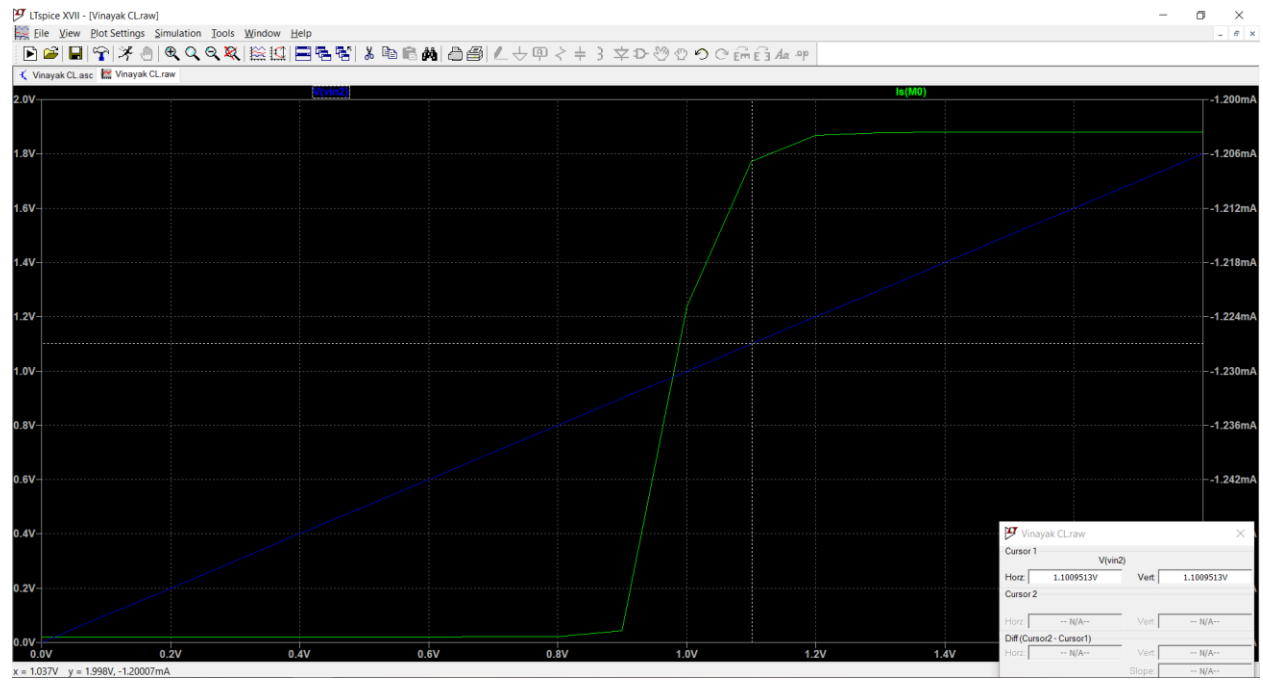
## 22. Bode Plot for common mode gain:



$$\text{CMRR}(@\text{DC}) = 20\log(A_d) - 20\log(A_{cm}) = 52 - (-26) = 78\text{dB}$$

### 23. ICMR-:

V1 Sweep from 0 to 1.8Volt & Current  $I_o$  is observed. At edge of saturation,  $V_{BIAS}$  value is noted as: 1.1V



Parameters of MOSFET:

Semiconductor Device Operating Points:

--- BSIM3 MOSFETS ---

Name:	m3	m4	m0a	m0	m2
Model:	cmosp	cmosp	cmosp	cmosp	cmosp
Id:	6.27e-04	6.32e-04	1.50e-03	1.26e-03	6.32e-04
Vgs:	-3.07e-01	-5.98e-01	0.00e+00	-4.53e-01	-2.87e-01
Vds:	5.67e-01	2.88e-01	6.76e-01	2.23e-01	3.90e-01
Vbs:	1.19e+00	9.02e-01	6.76e-01	2.23e-01	6.14e-01
Vth:	-6.82e-01	-6.80e-01	-5.09e-01	-5.10e-01	-5.76e-01
Vdsat:	-1.76e-01	-1.85e-01	-1.46e-01	-1.45e-01	-1.09e-01
Gm:	5.58e-03	5.13e-03	1.59e-02	1.29e-02	9.18e-03
Gds:	1.63e-04	4.43e-04	2.92e-04	1.16e-03	2.37e-04
Gmb:	1.44e-03	1.33e-03	4.77e-03	3.91e-03	2.57e-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:	3.81e-14	3.81e-14	1.14e-13	1.14e-13	1.14e-13
Cgdov:	3.81e-14	3.81e-14	1.14e-13	1.14e-13	1.14e-13
Cgbov:	1.21e-19	1.21e-19	1.21e-19	1.21e-19	1.21e-19
dQgdVgb:	1.28e-13	1.29e-13	3.86e-13	3.87e-13	3.79e-13
dQgdVdb:	-3.80e-14	-3.82e-14	-1.14e-13	-1.15e-13	-1.14e-13
dQgdVsb:	-8.98e-14	-8.99e-14	-2.67e-13	-2.67e-13	-2.60e-13
dQddVgb:	-5.84e-14	-5.87e-14	-1.75e-13	-1.76e-13	-1.72e-13
dQddVdb:	3.80e-14	3.83e-14	1.14e-13	1.15e-13	1.14e-13
dQddVsb:	2.55e-14	2.56e-14	7.93e-14	7.95e-14	7.40e-14
dQbdVgb:	-1.14e-14	-1.12e-14	-3.65e-14	-3.53e-14	-3.55e-14
dQbdVdb:	-2.71e-17	-2.82e-16	-2.13e-17	-1.29e-15	-9.93e-17
dQbdVsb:	6.49e-16	5.89e-16	-5.86e-15	-6.10e-15	-2.56e-15

Name:	m1	m6	m5	m7	m8
Model:	cmosp	cmosn	cmosn	cmosn	cmosn
Id:	6.27e-04	6.32e-04	6.27e-04	6.27e-04	6.32e-04
Vgs:	-2.75e-01	6.28e-01	6.34e-01	6.07e-01	6.07e-01
Vds:	4.02e-01	7.26e-01	4.42e-01	1.66e-01	1.72e-01
Vbs:	6.25e-01	-1.72e-01	-1.66e-01	0.00e+00	0.00e+00
Vth:	-5.76e-01	5.43e-01	5.43e-01	5.01e-01	5.01e-01
Vdsat:	-1.08e-01	8.51e-02	8.78e-02	9.25e-02	9.26e-02
Gm:	9.14e-03	9.75e-03	9.59e-03	8.93e-03	9.03e-03
Gds:	2.27e-04	2.62e-04	3.14e-04	8.61e-04	8.16e-04
Gmb:	2.56e-03	2.29e-03	2.27e-03	2.23e-03	2.26e-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:	1.14e-13	4.94e-14	4.94e-14	4.94e-14	4.94e-14
Cgdov:	1.14e-13	4.94e-14	4.94e-14	4.94e-14	4.94e-14
Cgbov:	1.21e-19	1.46e-19	1.46e-19	1.46e-19	1.46e-19
dQgdVgb:	3.79e-13	1.58e-13	1.59e-13	1.61e-13	1.61e-13
dQgdVdb:	-1.14e-13	-4.91e-14	-4.91e-14	-4.96e-14	-4.95e-14
dQgdVsb:	-2.60e-13	-1.03e-13	-1.04e-13	-1.05e-13	-1.05e-13
dQddVgb:	-1.72e-13	-7.20e-14	-7.23e-14	-7.33e-14	-7.33e-14
dQddVdb:	1.14e-13	4.92e-14	4.93e-14	4.98e-14	4.97e-14
dQddVsb:	7.39e-14	2.85e-14	2.89e-14	3.01e-14	3.01e-14
dQbdVgb:	-3.55e-14	-1.44e-14	-1.43e-14	-1.40e-14	-1.41e-14
dQbdVdb:	-8.93e-17	1.06e-17	-9.14e-18	-5.97e-16	-5.32e-16
dQbdVsb:	-2.55e-15	-3.08e-15	-3.18e-15	-4.50e-15	-4.49e-15