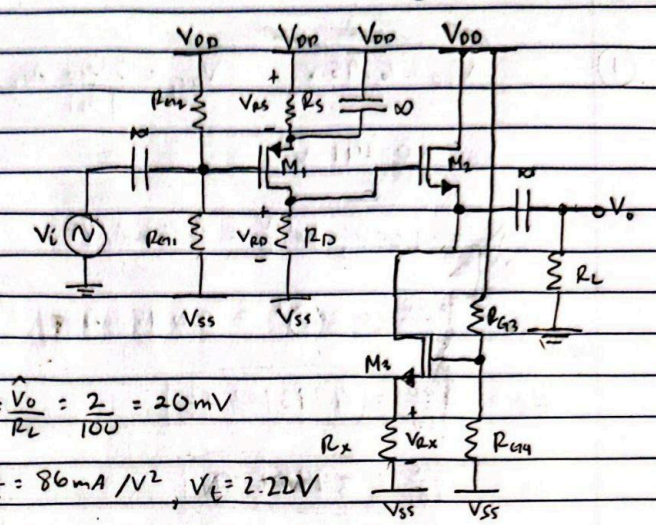
Calculations:

Lab 12

Elen 325

Nguyen

931006029



$V_{DD} = 5V$

$V_{SS} = -5V$

$R_L = 100\Omega$

$\hat{V}_o = 2V$

$|A_V| = 50$

$R_i = 10k\Omega$

$THD \leq 8\%$

$i_{D_2} = i_{D_3} = i_x \qquad i_x \geq \frac{\hat{V}_o}{R_L} = \frac{2}{100} = 20mV$

$\boxed{i_x = 25mV}$, $K_n' \frac{W}{L} = 86mA/V^2$, $V_t = 2.22V$

$i_x = \frac{K_n'}{2}\frac{W}{L}(V_{ov_2})^2 \Rightarrow 25m = \frac{86m}{2}(V_{ov_2})^2$

$\boxed{V_{ov_2} = 0.762\,V}$

$\boxed{V_{ov_3} = 0.762\,V}$

$g_{m_2} = (86m)(0.762) = \boxed{65.53\,mA/V}$

$\frac{1}{g_{m_2}} = \boxed{15.26\,\Omega}$

$A_{V_2} = \frac{R_L}{\frac{1}{g_{m_2}} + R_L} = \frac{100}{15.26 + 100} = \boxed{0.868} \Rightarrow A_{V_1} = \frac{50}{0.868} = 57.6$

$\hat{V}_d = \frac{\hat{V}_o}{A_{V_2}} = \frac{2}{0.868} = \boxed{2.305\,V}$

* Choose $V_{RS} = 0.5V$, $V_{RX} = 0.5V$

$V_{DD} + V_{SS} - \hat{V}_d - V_{RS} - V_{ov_1} \geq V_{RD} \Rightarrow V_{RD} \leq 10 - 2.305 - 0.5 - \frac{2V_{RD}A_{V_2}}{|A_{V_1}|}$

$V_{RD} \leq 7.195 - 0.03472V_{RD} \Rightarrow V_{RD} \leq 6.95\,V$

$V_{RD} \geq V_{RX} + V_{ov_3} + \hat{V}_o + V_{tn} + V_{ov_2} \Rightarrow 0.5 + 0.762 + 2 + 2.22 + 0.762 \leq V_{RD}$

$V_{RD} \geq 6.244\,V \Rightarrow$ choose $\boxed{V_{RD} = 6.95V}$

(1) $V_{RD} = 6.95\,V$ $\quad V_{ov_1} = \frac{2V_{RD}}{|A_{v1}|} A_{v2} \Rightarrow \frac{2(6.95)(0.868)}{50}$

$V_{ov_1} = 0.241\,V$

$V_{tp} = -1.65V,\ kp'\frac{W}{L} = 0.5\,mA/V^2$

$i_{D_1} = \frac{0.5m}{2}(0.241)^2 = 0.0145\,mA = \boxed{14.52\,\mu A}$

$R_D = \frac{V_{RD}}{i_{D_1}} = \boxed{479310\,\Omega}$

$R_S = \frac{V_{RS}}{i_{D_1}} = \boxed{34483\,\Omega}$

$R_x = \frac{V_{Rx}}{i_{D_3}} = \frac{0.5}{0.025} = \boxed{20\Omega}$

$V_{RG_2} = V_{RS} + |V_{tp}| + V_{ov_1} = 0.5 + 1.65 + 0.241 = 2.39\,V$

$R_{in} = R_{G_1} \| R_{G_2} \Rightarrow 10\,k\Omega = \frac{R_{G_1}R_{G_2}}{R_{G_1}+R_{G_2}} \Rightarrow R_{G_1}+R_{G_2} = \frac{R_{G_1}R_{G_2}}{10k\Omega}$

$V_{RG_2} = \frac{R_{G_2}(10)}{R_{G_1}+R_{G_2}} \Rightarrow 2.39 = \frac{R_{G_2}(10)}{R_{G_1}+R_{G_2}} \Rightarrow R_{G_1}+R_{G_2} = 4.184R_{G_2}$

$4.184R_{G_2} = \frac{R_{G_1}R_{G_2}}{10000} \Rightarrow \boxed{R_{G_1} = 41841\,\Omega}$ $\quad i_{RG_2} = \frac{2.39}{13141} = \boxed{181.95\,\mu A}$

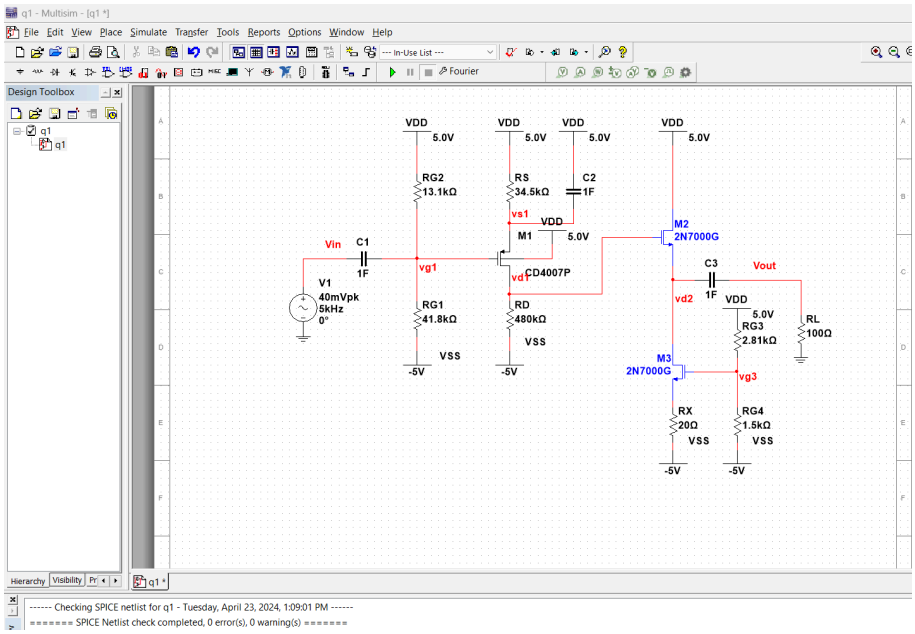
$2.39 = \frac{10R_{G_2}}{41841 + R_{G_2}} \Rightarrow \boxed{R_{G_2} = 13141\,\Omega}$

$V_{RG_4} = V_{Rx} + V_{tn} + V_{ov_3} = 0.5 + 2.22 + 0.762 = 3.48\,V$

$V_{RG_4} = \frac{R_{G_4}}{R_{G_3}+R_{G_4}}(10) \Rightarrow 0.348 = \frac{R_{G_4}}{R_{G_3}+R_{G_4}} \Rightarrow 0.348R_{G_3} = 0.652R_{G_4}$

$R_{G_3} = 1.874R_{G_4} \Rightarrow \boxed{R_{G_3} = 2.81k\Omega,\ R_{G_4} = 1.5\,k\Omega}$

Schematic:



Q1:

q1

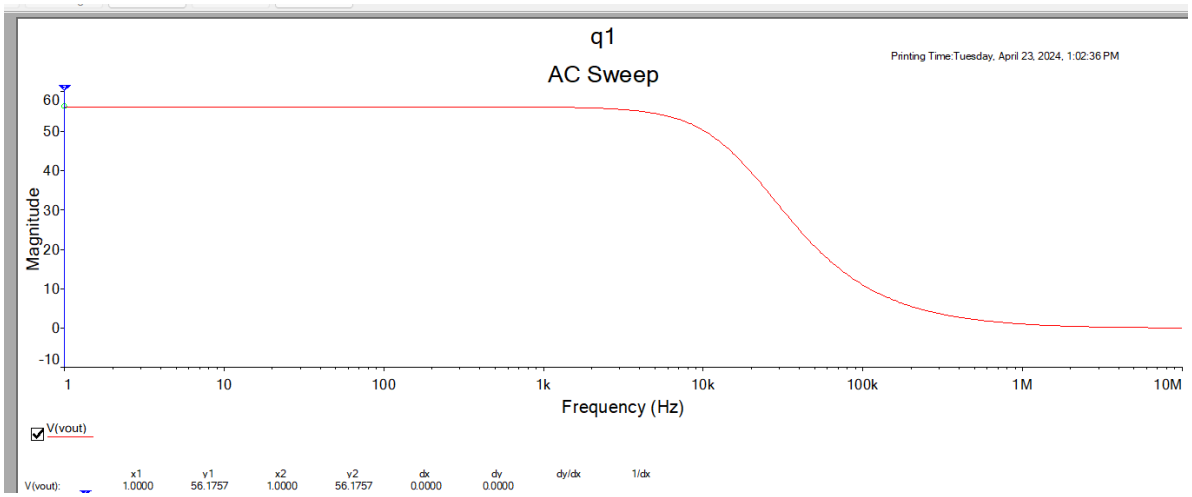
DC Operating Point Analysis

Printing Time:Wednesday, April 24, 2024, 11:20:53 AM

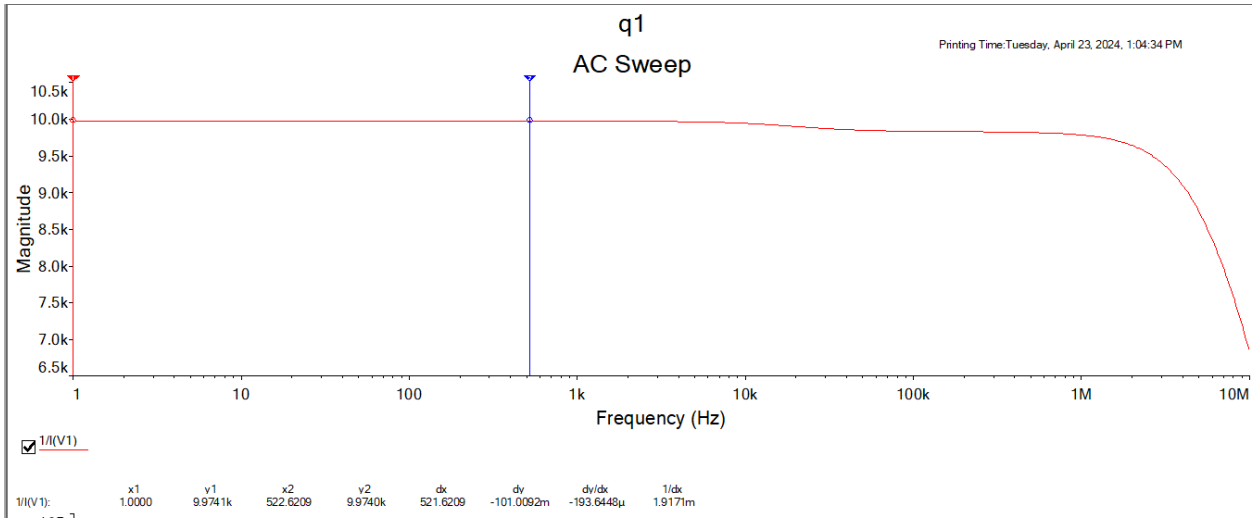
	Variable	Operating point value
1	V(vd1)	1.98170
2	V(vd2)	-1.00737
3	V(vg1)	2.61384
4	V(vg3)	-1.51972
5	V(vs1)	4.49819
6	I(RD)	14.54520 u
7	I(RG1)	182.14936 u
8	I(RG2)	182.14936 u
9	I(RS)	14.54515 u
10	I(RX)	24.56077 m

V_{G1} = 2.61V, V_{S1} = 4.5V, V_{D1} = V_{G2} = 1.98V, V_{D2} = 5V, V_{S2} = V_{D3} = -1V, V_{G3} = -1.52V, I_{RG2} = I_{RG1} = 182.15 uA I_{D1} = 24.56mA, I_{D2} = I_{D3} = 14.54uA

Q2 (A_V and R_i):

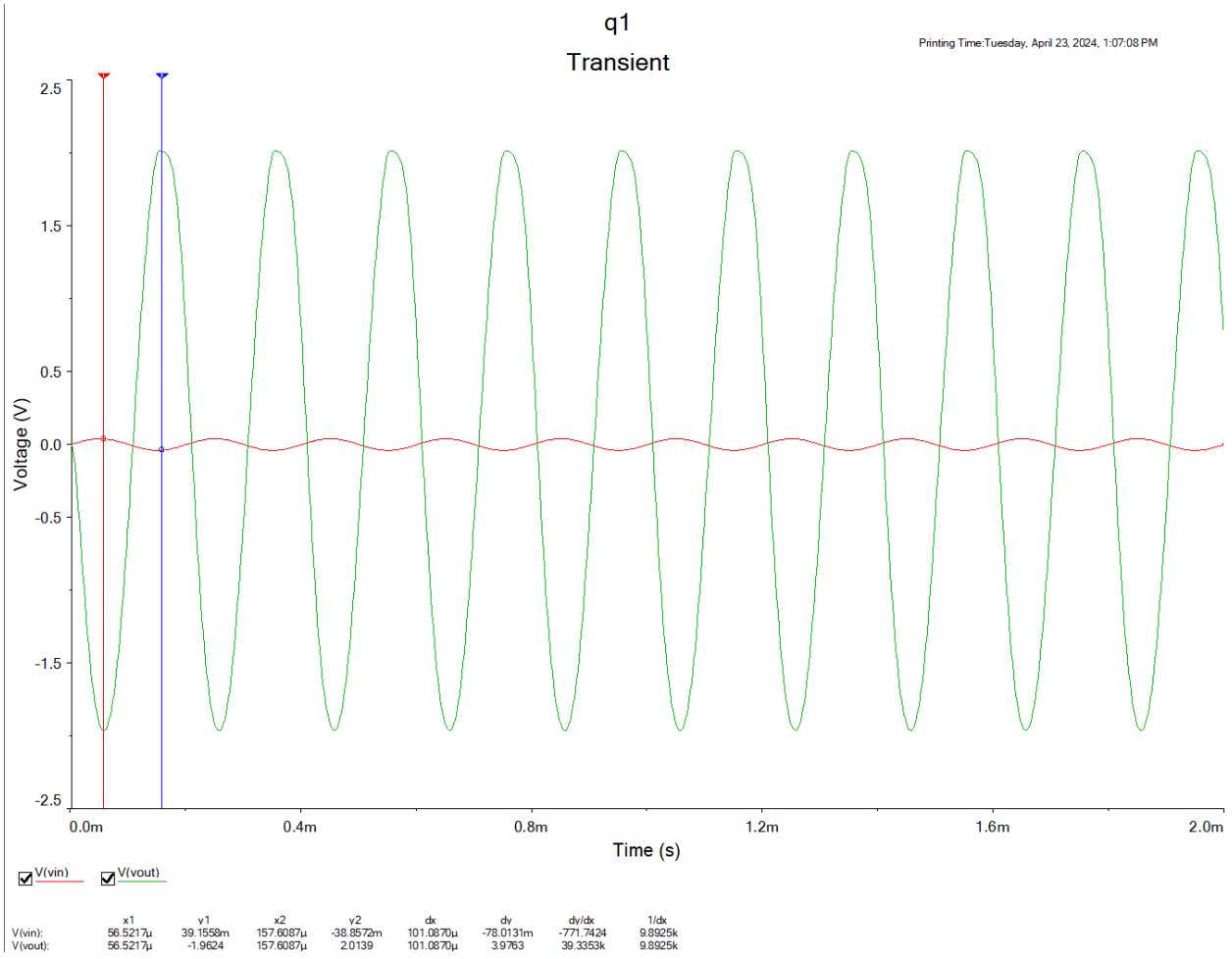


Here, A_V is 56.18 V/V



Here the Ri is about 9.974 kΩ

Q3:



The output signal here shows a 2.0139 V amplitude.

Q4:

q1

Printing Time:Tuesday, April 23, 2024, 1:08:20 PM

1	Fourier analysis for V(vou					
2	DC component:	0.0656737				
3	No. Harmonics:	9				
4	THD:	5.17322 %				
5	Grid size:	256				
6	Interpolation Degree:	1				
7						
8	Harmonic	Frequency	Magnitude	Phase	Norm. Mag	Norm. Phase
9	0	0	0.0656737	0	0.0317912	0
10	1	5000	2.06578	164.739	1	0
11	2	10000	0.0748615	134.73	0.0362389	-30.009
12	3	15000	0.0697072	133.418	0.0337438	-31.321
13	4	20000	0.0272748	149.047	0.0132032	-15.692
14	5	25000	0.0123356	-146.45	0.0059714	-311.19
15	6	30000	0.00579143	-65.162	0.00280351	-229.9
16	7	35000	0.00384757	30.6202	0.00186253	-134.12
17	8	40000	0.0030477	109.433	0.00147533	-55.306
18	9	45000	0.00188263	-162.59	0.000911342	-327.33
19						

Here the THD is about 5.17%