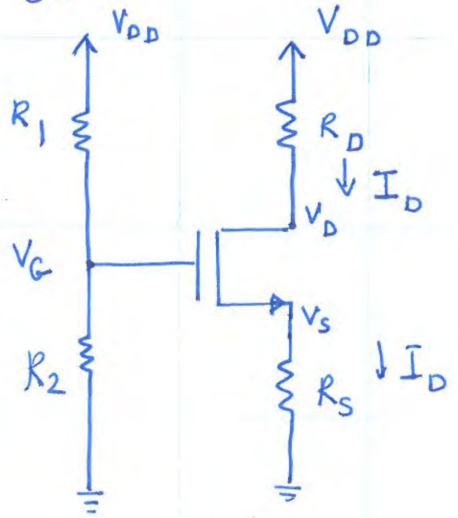
Homework 7 - solution

Problem 1

a) To design this amplifier, we must find R_D, R_S, R_1 and R_2.

At DC



- We have $A_V = -10\ V/V$ and $A_V = -\dfrac{2I_D}{V_{OV}}\left(R_D \parallel R_L \parallel r_o\right)$

- Finding V_{OV}:

$$I_D = \frac{1}{2} K' \frac{W}{L} V_{OV}^2 \left(1 + \lambda V_{DS}\right) \qquad \text{(saturation region)}$$

$$V_{OV}^2 = \frac{I_D}{\frac{1}{2} K' \frac{W}{L}\left(1 + \lambda V_{DS}\right)}$$

$$= \frac{0.2}{\frac{1}{2} \times 1.1 \times \left(1 + 3 \times 0.12\right)} \quad ; \text{ thus } V_{OV} = 0.517\ V$$

- finding r_o:

$$r_o = \frac{V_{DS} + V_A}{I_D} = \frac{3 + \frac{1}{0.12}}{0.2} = 56.67\ K\Omega$$

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- Finding R_D

$$A_V = -\frac{2I_D}{V_{ov}}\left(R_D \parallel R_L \parallel r_o\right)$$

$$A_V = -\frac{2I_D}{V_{ov}}\left(\frac{1}{\frac{1}{R_D}+\frac{1}{R_L}+\frac{1}{r_o}}\right)$$

$$\frac{1}{R_D} = -\frac{2I_D}{V_{ov} \cdot A_V} - \frac{1}{R_L} - \frac{1}{r_o}$$

$$= -\frac{2 \times 0.2}{0.517 \times (-10)} - \frac{1}{39} - \frac{1}{56.67}$$

$$R_D = 29.34\ K\Omega$$

- Finding R_s

$V_{DD} - V_D = R_D I_D$ thus $V_D = V_{DD} - R_D I_D$

$= 9 - 29.34 \times 0.2$

$= 3.132\ V$

$V_{DS} = V_D - V_S$ thus $V_S = V_D - V_{DS}$

$= 3.132 - 3$

$= 0.132\ V$

$$R_S = \frac{V_S}{I_D} = \frac{0.132}{0.2} = 0.66\ V.$$

- Finding R_1 and R_2.

$V_{OV} = V_{GS} - V_t = V_G - V_S - V_t$ thus $V_G = V_{OV} + V_S + V_t$

$= 0.517 + 0.132 + 0.8$

$= 1.449\ V.$

We have $R_{in} = 3\ M\Omega$.

and $R_{in} = \dfrac{R_1 R_2}{R_1 + R_2} \iff R_1 + R_2 = \dfrac{R_1 R_2}{R_{in}}$

We have $\dfrac{V_G}{V_{DD}} = \dfrac{R_2}{R_1 + R_2}$

$$\frac{V_G}{V_{DD}} = \frac{R_2}{\dfrac{R_1 R_2}{R_{in}}} = \frac{R_{in}}{R_1}$$

Thus $R_1 = \dfrac{R_{in}}{\dfrac{V_G}{V_{DD}}} = \dfrac{3\ M}{\dfrac{1.449}{9}} = 18.63\ M$.

$$R_2 = \frac{V_G}{\dfrac{V_{DD} - V_G}{R_1}} = \frac{1.449}{\dfrac{9 - 1.449}{18.63}} = 3.575\ M.$$

b)

When we have an input signal $v_s = 0\ V$ and $v_i = v_{gs}$

1) $I_D = 0 \iff$ Mosfet in cutoff region.

To compute the largest input signal that results in $I_D = 0$, we have $v_{GS} = V_t$

$$v_{GS} = V_t$$

$$v_{gs} + V_{GS} = V_t$$

$$v_{gs} = 0.8 - (1.449 - 0.132)$$

$$= -0.517\ V$$

Thus $v_{i_{max}} = -0.517\ V$.

Therefore $v_{i\ peak} = 0.517\ V$

2) $v_{DS} = v_{OV}$

$$V_{DS} + v_o = V_{ov} + v_i$$

$$-10\, v_i - v_i = V_{ov} - V_{DS}$$

$$-11\, v_i = 0.517 - 3$$

$$v_i = 0.226\ \text{V}$$

3) $v_{gs} = 0.1 \times V_{oV}$

$$v_i = 0.1 \times 0.517$$

$$= 0.0517\ \text{V}$$

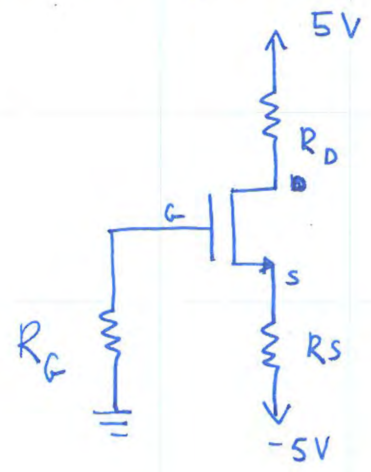
$$= 51.7\ \text{mV}$$

Thus

$$v_{i\,peak} \ll 51.7\ \text{mV}$$

Problem 2

$V_t = 0.7\,V$; $K'\frac{W}{L} = 1.1\,mA/V^2$ $\quad V_A = \frac{1}{\lambda} = 22V$



a) $R_G = 3\,M\Omega$.

• $V_{DS} > V_{GS} - V_t$ $\quad$ ($V_G = 0$ at DC since $I_G = 0$, and $V_G = R_G I_G$)

$V_D > V_G - V_t = 0 - 0.7 = -0.7\,V$

$V_{D\,min} = -0.7V$

V_D ↑ 1.5V, ↕ _1.5V, -0.7V here v_D should not be less than -0.7V

Thus $V_D - 1.5 = -0.7$

$V_D = -0.7 + 1.5 = 0.8V$

$$R_D = \frac{5 - V_D}{I_D} = \frac{5 - 0.8}{0.4} = 10.5\,k\Omega.$$

$$I_D = \frac{1}{2} K'\frac{W}{L}(V_{GS} - V_t)^2\left(1 + \frac{V_{DS}}{V_A}\right)$$

$$I_D = \frac{1}{2} K'\frac{W}{L}(-V_S - V_t)^2\left(1 + \frac{V_D - V_S}{V_A}\right)$$

$$\left(V_S + V_t\right)^2 \left(1 + \frac{V_D - V_S}{V_A}\right) = \frac{2I_D}{K'\frac{W}{L}}$$

$$\left(V_S + 0.7\right)^2 \left(1 + \frac{0.8 - V_S}{22}\right) = \frac{2 \times 0.4}{1.1}$$

$$\left(V_S + 0.7\right)^2 \left(22 + 0.8 - V_S\right) = 16$$

$$\left(V_S^2 + 1.4V_S + 0.49\right)\left(22.8 - V_S\right) = 16$$

$$22.8V_S^2 - V_S^3 + 31.92V_S - 1.4V_S^2 + 11.172 - 0.49V_S = 16$$

$$-V_S^3 + 21.4V_S^2 + 31.43V_S - 4.828 = 0$$

$$V_S = 22.77 \text{ or } -1.511 \text{ or } 0.14$$

We need $V_{GS} > V_t \rightarrow -V_S > V_t \rightarrow V_S < -0.7$

Thus $V_S = -1.511\ V$

$$R_S = \frac{V_S + 5}{I_D} = \frac{-1.511 + 5}{0.4} = 8.7225\ K\Omega$$

b) $V_{DS} = V_D - V_S = 0.8 + 1.511 = 2.311\ V.$

$$V_{GS} = -V_S = 1.511\ V$$

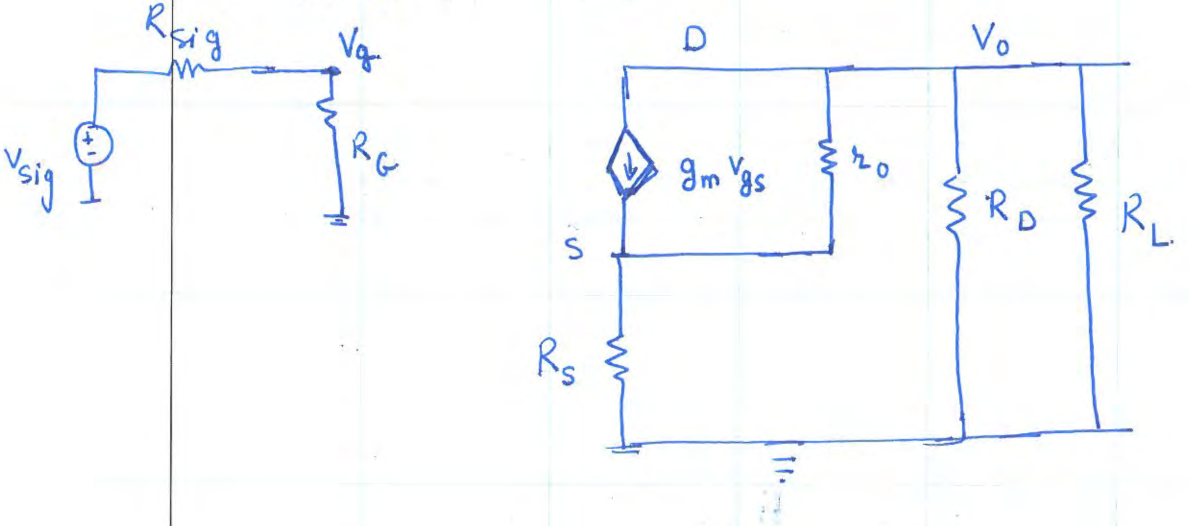
$$V_{OV} = V_{GS} - V_t = 1.511 - 0.7 = 0.811\ V$$

$$g_m = \frac{2I_D}{V_{OV}} = \frac{2 \times 0.4}{0.811} = 0.986\ mA/V$$

$$r_o = \frac{V_{DS} + V_A}{I_D} = \frac{2.311 + 22}{0.4} = 60.78\ K\Omega$$

c) ~~smatk~~ Finding A_{vo}

small signal model



$$g_m v_{gs} + \frac{V_s - V_o}{r_o} = \frac{V_s}{R_s} \quad ; \quad \frac{V_s}{R_s} = -\frac{V_o}{(R_D \parallel R_L)}$$

$$g_m V_g - g_m V_s + \frac{1}{r_o}(V_o - V_s) = \frac{1}{R_s} V_s$$

$$g_m V_g = g_m V_s - \frac{1}{r_o}(V_o - V_s) + \frac{1}{R_s} V_s$$

$$= \left(g_m + \frac{1}{r_o} + \frac{1}{R_s}\right) V_s - \frac{1}{r_o} V_o$$

$$g_m V_g = \left[-\frac{R_s}{R_D \parallel R_L}\left(g_m + \frac{1}{r_o} + \frac{1}{R_s}\right) - \frac{1}{r_o}\right] V_o$$

$$\frac{V_o}{V_g} = \frac{g_m}{\frac{-R_s}{(R_D \parallel R_L)}\left(g_m + \frac{1}{r_o} + \frac{1}{R_s}\right) - \frac{1}{r_o}} = -\frac{g_m r_o (R_D \parallel R_L)}{r_o(R_s g_m + 1) + R_s + (R_D \parallel R_L)}$$

$$\frac{V_g}{V_{sig}} = \frac{R_G}{R_G + R_{sig}}$$

$$A_v = \frac{v_o}{v_{sig}} = -\frac{R_G}{R_G + R_{sig}} \cdot \frac{g_m r_o \, (R_D \parallel R_L)}{r_o(1 + g_m R_s) + R_D \parallel R_L + R_s}$$

$$= -\frac{3\times10^3}{3\times10^3 + 39} \cdot \frac{0.986 \times 60.78 \, (10.5 \parallel 120)}{60.78(1 + 0.986 \times 8.7225) + (10.5 \parallel 120) + 8.7225}$$

$$= -0.949 \text{ V/V}$$

$$A_i = \frac{i_o}{i_i} = \frac{v_o / R_L}{\frac{v_{sig}}{(R_{sig} + R_G)}} = A_v \cdot \frac{R_{sig} + R_G}{R_L}$$

$$= -0.949 \cdot \frac{3\times10^3 + 39}{120}$$

$$= -24.03 \text{ A/A}.$$

$$A_p = A_i \, A_v = 22.8 \text{ W/W}$$

d) If we try to $\downarrow R_S$, $A_v \uparrow$ (from the above equation).

Since we need the bias conditions to not be disrupted, a capacitor can be used to bypass part of the resistor R_S.

(The capacitor should be very large so that it has infinite impedance at DC).

HW8

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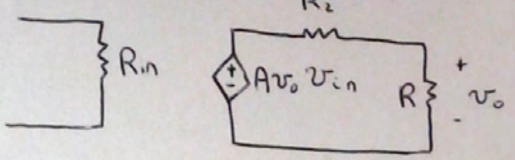
Problem 1:



a) b)

* For $R = 33k\Omega$

$$v_o = \frac{33}{33 + R_2} Av_o v_{in}$$

$$\frac{v_o}{v_{in}} = \frac{33}{33 + R_2} Av_o = 99$$

* For $R = 39k\Omega$,

$$\frac{v_o}{v_{in}} = \frac{39}{39 + R_2} Av_o = 108$$

$$\begin{cases} 33 Av_o = 99(33 + R_2) \\ 39 Av_o = 108(39 + R_2) \end{cases}$$

Solving these 2 equations with 2 unknowns we get:

$$\boxed{Av_o = 216 \text{ V/V}}$$

$$\boxed{R_2 = 39 \text{ k}\Omega}$$

c) With $47k\Omega$ resistance,

$$v_{in} = \frac{R_{in}}{R_{in} + 47} v_{sig} = 0.76\, v_{sig}$$

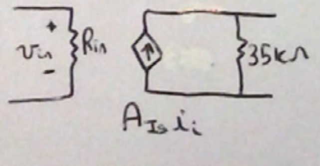
$$\Rightarrow R_{in} = 0.76(R_{in} + 47)$$

$$R_{in}(1 - 0.76) = 47 \times 0.76$$

$$\boxed{R_{in} = 148.83\ k\Omega}$$

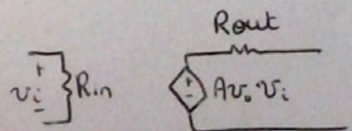
Problem 2:

$R_{in} = 150k\Omega$ $\quad A_{Is} = 200$ A/A

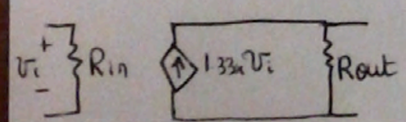


$$Av_o = G_m R_{out} = \frac{A_{is}}{R_{in}} \times R_{out} = \boxed{46.67 \text{ V/V}}$$

$$G_m = \frac{Av_o}{R_o} = \frac{46.67}{35} = \boxed{1.33 \text{ mA/V}}$$

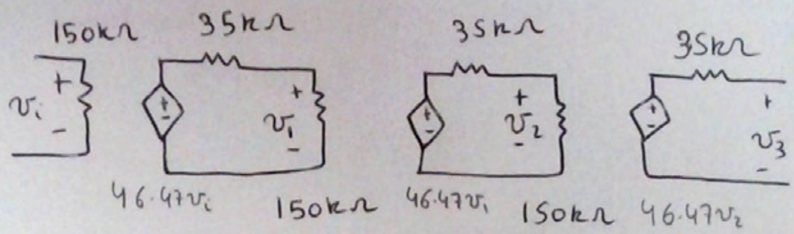


$Av_o = 46.67$ V/V



$G_m = 1.33$ mA/V

b)



$$R_{in} = \frac{v_i}{i_i} = 150k\Omega$$

$$R_{out} = \frac{V_x}{i_x}\Big|_{v_{in}=0} = 35k\Omega$$ (V_x and i_x are test voltage and current)

$$v_1 = \frac{150}{150+35} \times 46.47 v_i \Rightarrow Av_1 = \frac{v_1}{v_{in}} = 36.68 \text{ V/V}$$

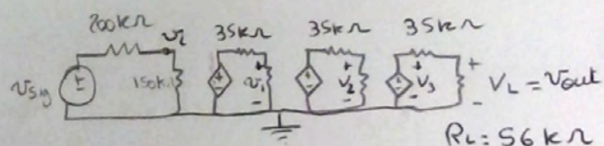
$$v_2 = \frac{150}{150+35} \times 46.47 v_1 \Rightarrow Av_2 = 36.68 \text{ V/V}$$

$$v_3 = 46.47\, v_2 \Rightarrow Av_3 = 46.47$$

$$Av_o = \frac{v_{out}}{v_{in}} = \frac{v_3}{v_i} = \frac{v_3}{v_2} \times \frac{v_2}{v_1} \times \frac{v_1}{v_i} = Av_3 \times Av_2 \times Av_1 = 65\,971 \text{ V/V}$$

$$Ai_s = \frac{R_{in}}{R_{out}} Av_o = 282732 \text{ A/A}$$

$$G_m = \frac{Av_o}{R_{out}} = 1.88 \text{ A/V}$$



c) $$v_o = V_L = \frac{56}{56+35} \times v_3 = 28.6\, V_2$$

$$v_i = \frac{150}{150+200} v_{sig} = 0.428\, v_{sig}$$

$$\frac{v_{out}}{v_i} = \frac{v_{out}}{v_3} \times \frac{v_3}{v_2} \times \frac{v_2}{v_1} \times \frac{v_1}{v_i} = 0.614\, Av_o = 40\,597 \text{ V/V}$$

$$\frac{v_{out}}{v_{sig}} = \frac{v_{out}}{v_i} \times \frac{v_i}{v_{sig}} = 17\,399 \text{ V/V}$$ in dB, $\frac{v_{out}}{v_{sig}} = 84.8$ dB

$$\frac{i_{out}}{i_{sig}} = \frac{v_{out}/R_L}{v_{sig}/(R_{in}+R_{sig})} = \frac{v_{out}}{v_{sig}} \times \frac{150+200}{56} = 108743 \text{ A/A}$$

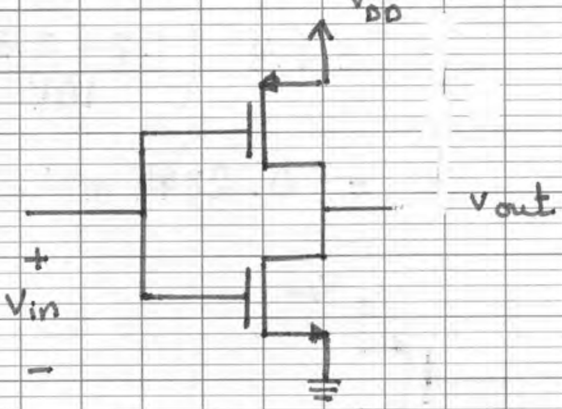
in dB, $A_i = 20\log(A_{i(A/A)}) = 100 \text{ dB}$

$$A_p = \frac{v_{out}}{v_{sig}} \times \frac{i_{out}}{i_{sig}} = 1.89 \times 10^9 \text{ W/W}$$

in dB, $A_p = 10 \log A_{P(W/W)} = 92.77 \text{ dB}$

EECE 310 _ Homework 9

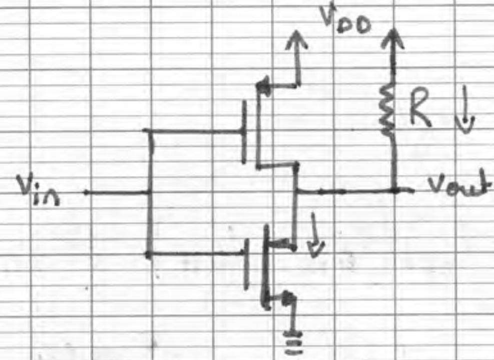
Problem 1



a) $V_{OH} = V_{DD} = 1.8V$

$V_{OL} = 0V.$

b)



For Nmos: $\begin{cases} V_{GS_n} = 1.8V \\ V_{OL} \text{ is smal} \end{cases} \rightarrow$ triode region

For Pmos: $\{ V_{GSp} = V_{DD} - V_{DD} = 0V \rightarrow$ Cutoff region

$$\frac{1}{2} K'_n \left(\frac{W}{L}\right)_n \left(2 (V_{GSn} - V_{tn}) V_{OL} - V_{OL}^2 \right) = \frac{V_{DD} - V_{OL}}{R}$$

$$\frac{1}{2} \times 330 \times \frac{0.4}{0.18} \times 10^{-3} \left(2 (1.8 - 0.6) V_{OL} - V_{OL}^2 \right) = \frac{1.8 - V_{OL}}{10}$$

$$\frac{11}{3} \left(2.4 V_{OL} - V_{OL}^2 \right) = 1.8 - V_{OL}$$

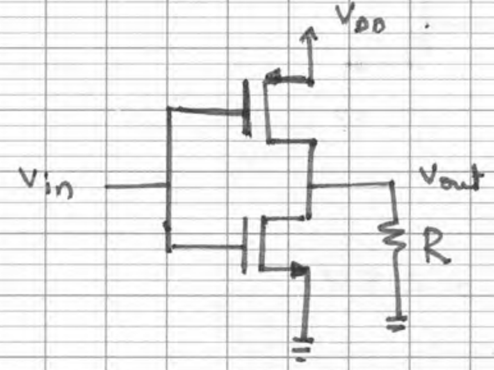
$$-\frac{11}{3} V_{OL}^2 + 9.8 V_{OL} - 1.8 = 0 \rightarrow \boxed{V_{OL} = 0.198V}$$

Power dissipated : $P = V_{DD} I_D = V_{DD} \cdot \left(\frac{V_{DD} - V_{OL}}{R} \right)$

$$= 1.8 \left(\frac{1.8 - 0.198}{10K} \right)$$

$$= 0.288 \text{ mW}$$

c)



Nmos → cutoff
Pmos → triode region

$$\frac{1}{2}K'_p \left(\frac{W}{L}\right)_p \left[(V_{GSp} - V_{tp})(V_{OH} - V_{DD}) - \frac{1}{2}(V_{OH} - V_{DD})^2 \right] = \frac{V_{OH}}{R}$$

$$\frac{1}{2} \times 170 \times 10^{-3} \times \frac{0.8}{0.18} \left[2 \times (-1.8 + 0.7)(V_{OH} - 1.8) - (V_{OH} - 1.8)^2 \right] = \frac{V_{OH}}{10}$$

$$\frac{34}{9} \left[-2.2 (V_{OH} - 1.8) - (V_{OH} - 1.8)^2 \right] = V_{OH}$$

$$\frac{34}{9} \left(-2.2 V_{OH} + 3.96 - V_{OH}^2 + 3.6 V_{OH} - 3.24 \right) = V_{OH}$$

$$-34 V_{OH}^2 + 38.6 V_{OH} + 24.48 = 0$$

$$\boxed{V_{OH} = 1.59 \text{ V}}$$

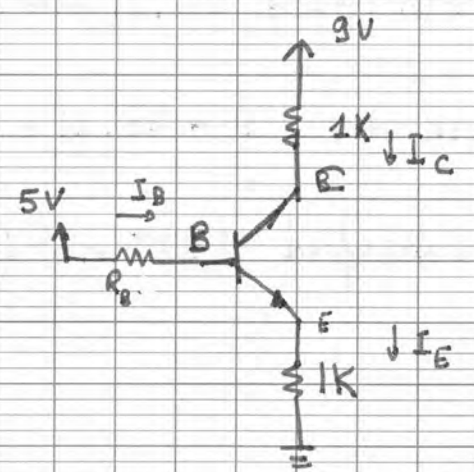
$$P = V_{DD} \cdot I_D = V_{DD} \cdot \frac{V_{OH}}{R} = 1.8 \times \frac{1.59}{10} = 0.2862 \text{ mW}$$

d) $P_{dyn} = C f \cdot V_{DD}^2$

$= 50 \times 10^{-15} \times \frac{1}{2 \times 10^{-9}} \times (1.8)^2$

$= 81 \mu W$.

Problem 2



$|V_{BE}| = 0.7$

$I_B = 30 \mu A$

$\beta = 120$

a) BJT active

$I_E = (\beta+1) I_B = 121 \times 30 = 3630 \mu A = 3.63 mA$.

$R_B = \frac{5 - V_B}{I_B} = \frac{5 - (V_{BE} + V_E)}{I_B} = \frac{5 - (V_{BE} + 1K \times I_E)}{I_B}$

$= \frac{5 - 0.7 - 3.63}{30 \times 10^{-3}} = 22.33 k\Omega$

b) $I_C = \beta I_B = 120 \times 30 = 3.6 mA$.

$9 - V_C = 1K \times I_C = 3.6 \rightarrow V_C = 5.4V$.

$V_{CE} = V_C - V_E = 5.4 - 3.63 = 1.77V$.

$V_{CE} > 0.3V \rightarrow$ BJT active region.

c) Assume BJT is still in active regim.

$V_{BE} = 0.7\,V \rightarrow V_B = 0.7\,V.$

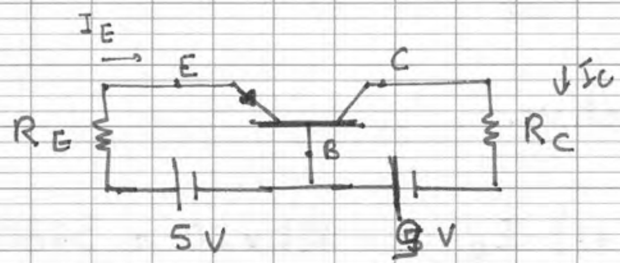
$$I_B = \frac{5-0.7}{22.33} = 0.192\ mA.$$

$I_c = \beta I_B = 120 \times 0.192 = 23.11\ mA.$

$V_{CE} = V_C = -I_C \times 1K + 9 = 9 - 23.11 = -14.11 < 0.3V$

$\rightarrow$ Condition not satisfied (BJT not in active region).

Problem 3



$\alpha = 0.989$
$I_E = 0.15\,mA$
$V_{EC} = 3.3\,V$

Assume BJT in active regim.
$V_{EB} = 0.7\,V$

$$V_{EB} - 5 + R_E I_E = 0$$
$$0.7 - 5 + R_E \times 0.15 = 0$$
$$R_E = \frac{5-0.7}{0.15} = 28.67\,K\Omega$$

$$I_C = \alpha I_E = 0.989 \times 0.15$$
$$= 0.1485 \text{ mA} .$$

$$-9 - 5 + R_E I_E + V_{EC} + R_C I_C = 0$$

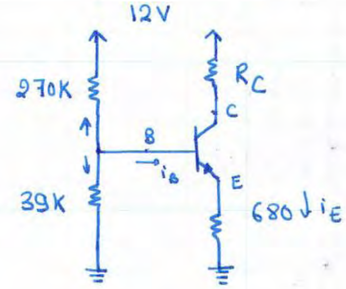
$$-14 + 4.3 + 3.3 + R_C \times 0.1485 = 0$$

$$\boxed{R_C = 43.10 \text{ K}\Omega}$$

EECE 310- Homework 10

Problem 1

a)



$\beta = 150$

(1) KCL at B : $\frac{V_B - 12}{270} + \frac{V_B}{39} + i_B = 0$ (i_B in mA)

(2) $V_B = V_{BE} + V_E = 0.7 + 680 \times 10^{-3}\, i_E$; $i_E = (\beta+1)\, i_B$

$= 0.7 + 680 \times 10^{-3} \times 151\, i_B$

$V_B = 0.7 + 103.38\, i_B$.

From (1) $\frac{0.7 + 103.38 i_B - 12}{270} + \frac{0.7 + 103.38 i_B}{39} + i_B = 0$

$i_B = 5.926 \times 10^{-3}$ mA .

$V_E = 680 \times 10^{-3} \times 151 \times i_B = 0.608\,V$.

$V_{CE} > 0.3V$ (active region).

$V_C > V_E + 0.3 = 0.908\,V$.

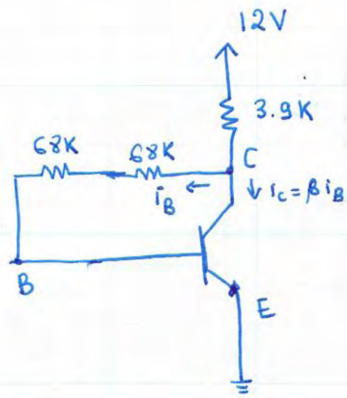
b) $V_C = \frac{12 + 0.908}{2} = 6.454\,V$.

$R_C = \frac{12 - V_C}{\beta i_B} = \frac{12 - 6.454}{150 \times 5.926 \times 10^{-3}} = 6.24\,K\Omega$

Problem 2

$\beta = 160$, $V_A = 80\,V$, $V_T = 26\,mV$

a) DC



$$V_{BE} = 0.7\,V \rightarrow V_B = 0.7\,V$$

(1) $\dfrac{12 - V_C}{3.9K} = (\beta + 1) I_B$

(2) $\dfrac{V_C - 0.7}{136K} = I_B$

$$\frac{\dfrac{12 - V_C}{3.9}}{\dfrac{V_C - 0.7}{136}} = \beta + 1 = 161$$

$$\frac{12 - V_C}{3.9} = \frac{161}{136}(V_C - 0.7)$$

$$\left(\frac{161}{136} + \frac{1}{39}\right) V_C = \frac{12}{39} + 0.7 \cdot \frac{161}{136} \quad ; \; V_C = 2.711\,V = V_{CE}.$$

$$I_B = \frac{V_C - 0.7}{136K} = \frac{2.711 - 0.7}{136K} = 14.787 \times 10^{-3}\,mA.$$

$$I_C = \beta I_B = 160 \times 14.787 \times 10^{-3} = \cancel{0.1418}\ 2.366\,mA.$$

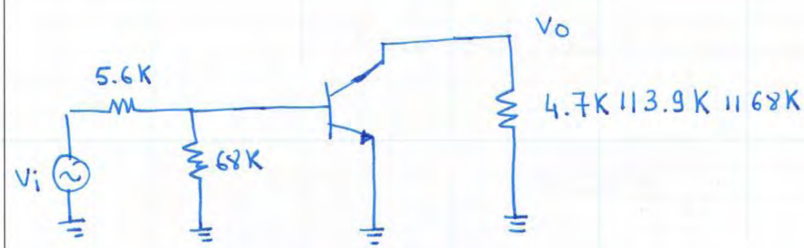
b) $g_m = \frac{I_C}{V_T} = \frac{2.366}{26} = 0.091\ A/V$

$r_\pi = \frac{\beta}{g_m} = \frac{160}{0.091} = 1.76\ K\Omega$

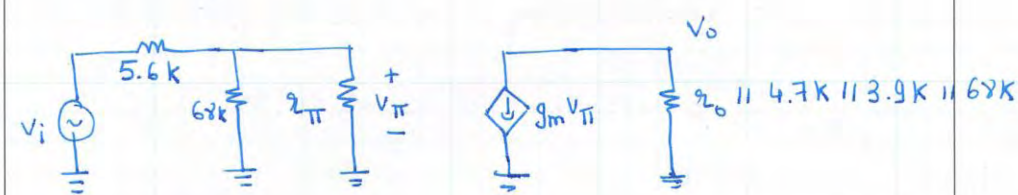
$r_e = \frac{\alpha}{g_m} = \frac{\beta}{(\beta+1)\, g_m} = \frac{160}{161 \times 0.091} = 10.92\ \Omega.$

$r_o = \frac{V_A + V_{CE}}{I_C} = \frac{80 + 2.711}{2.366} = 34.96\ K\Omega$

c) Small signal analysis



Small signal model



$V_o = -g_m\, V_\pi\ (r_o \parallel 4.7k \parallel 3.9k \parallel 68k)$

$\frac{V_o}{V_\pi} = -0.091 \times (34.96K \parallel 4.7K \parallel 3.9k \parallel 68K) = -177.56\ V/V$

$\frac{V_\pi}{V_i} = \frac{68K \parallel r_\pi}{5.6K + 68K \parallel r_\pi} = \frac{68K \parallel 1.76K}{5.6K + 68K \parallel 1.76K} = 0.234\ V/V$

$\frac{V_o}{V_i} = -177.56 \times 0.234 = -41.55\ V/V.$

d)

- In active region

$$v_{CE} > 0.3$$

$$V_{CE} + v_{ce} > 0.3$$

$$2.711 + v_{CE} > 0.3$$

$2.711 + v_p$ — v^+_{peak}
2.711
$2.711 - v_{p2}$ — v^-_{peak}
thus we sould ensure that this value $> 0.3V$

$$2.711 - v_{peak2} > 0.3$$

$$v_{peak2} < 2.711 - 0.3 = 2.411\ V$$

$$v_{\substack{peak\text{-}to\text{-}peak \\ max}} = 2 \times 2.411 = 4.822V.$$

- $v_{bc} \leq 5\,mV$

We have $\frac{v_o}{v_\pi} = \frac{v_c}{v_b} = -117.56\ V/V$

$$v_c = -117.56\, v_b \;\; ; \text{ we have } v_b \leq 5 \times 10^{-3}\ V$$

$$v_c \geq -117.56 \times 5 \times 10^{-3} = -0.8878\ V.$$

V_C

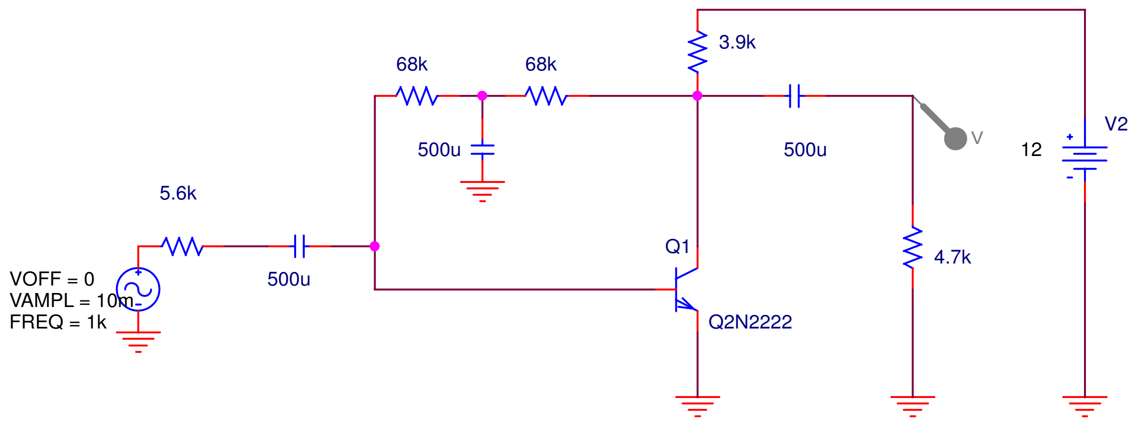
$-0.8878 + V_C$

$$V_{p\text{-}to\text{-}p} = 2 \times 0.8878 = 1.7756\ V.$$

Thus the maximum signal swing is 1.7756V.

- $v_o = -41.55\, v_i$

$$v_{i\,p\text{-}p} = \frac{1.7756}{41.55} = 42.73\,mV.$$



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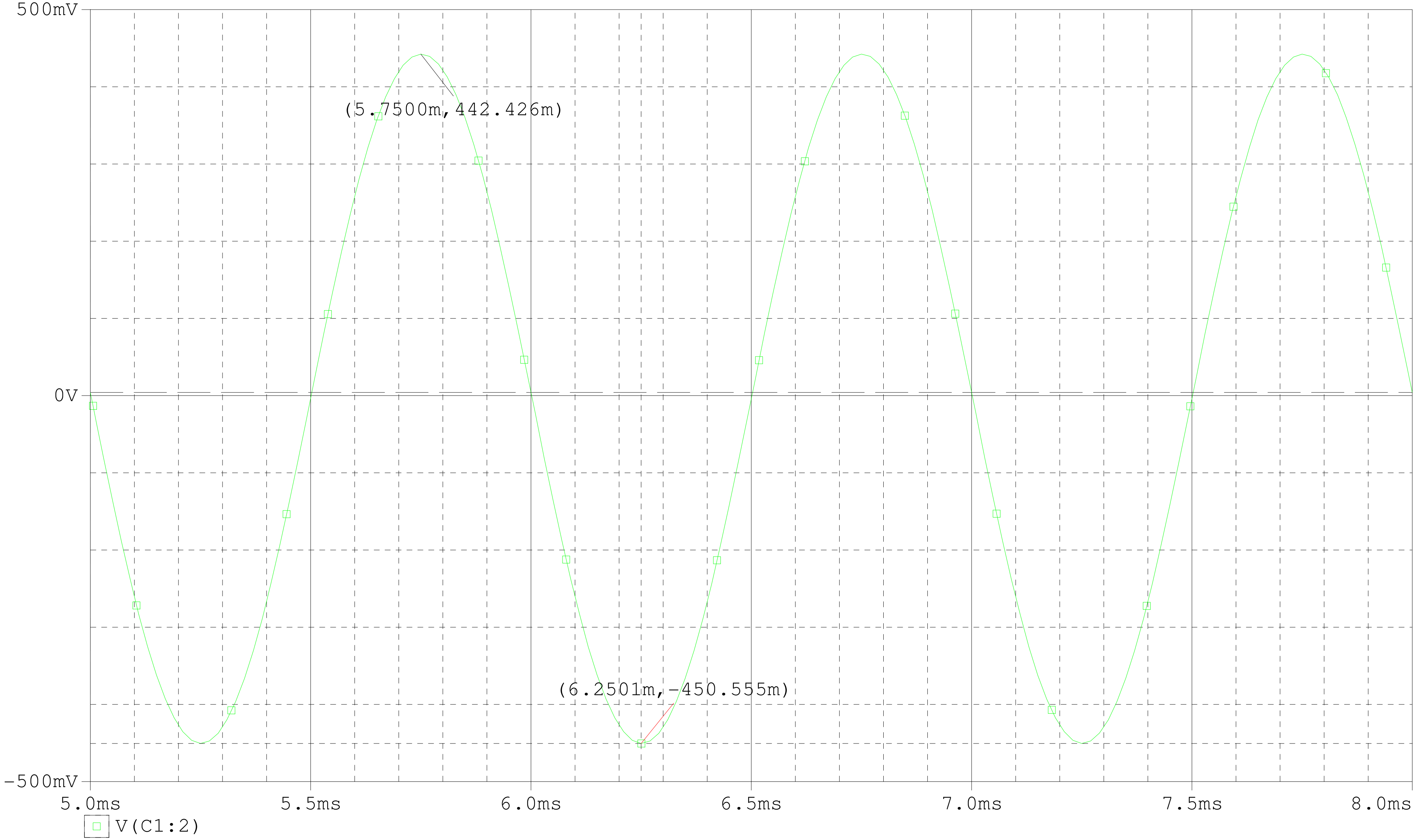
** Profile: "SCHEMATIC1-zxx" [C:\Users\Hawraa\Documents\dasdf-SCHEMATIC1-zxx.sim]
Date/Time run: 01/09/12 00:02:39 Temperature: 27.0

(A) dasdf-SCHEMATIC1-zxx.dat (active)



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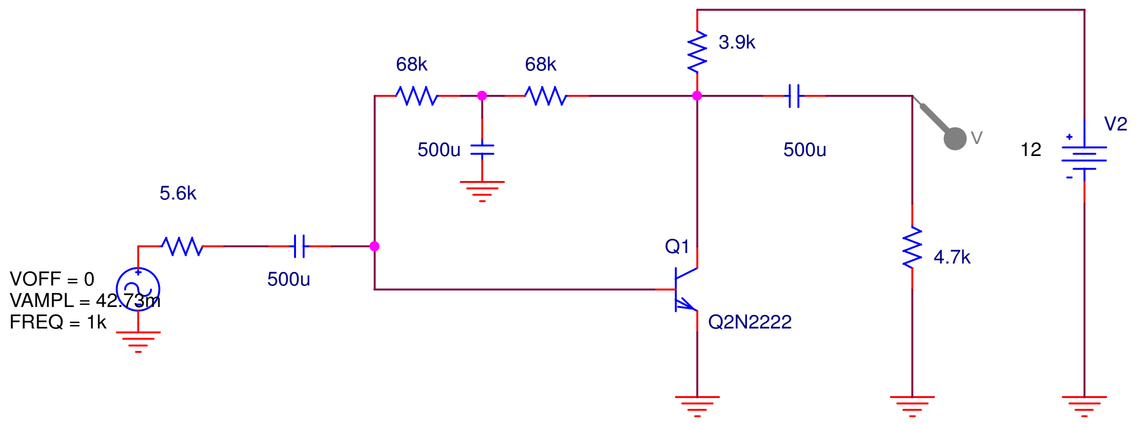

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** Profile: "SCHEMATIC1-zxx" [C:\Users\Hawraa\Documents\dasdf-SCHEMATIC1-zxx.sim]

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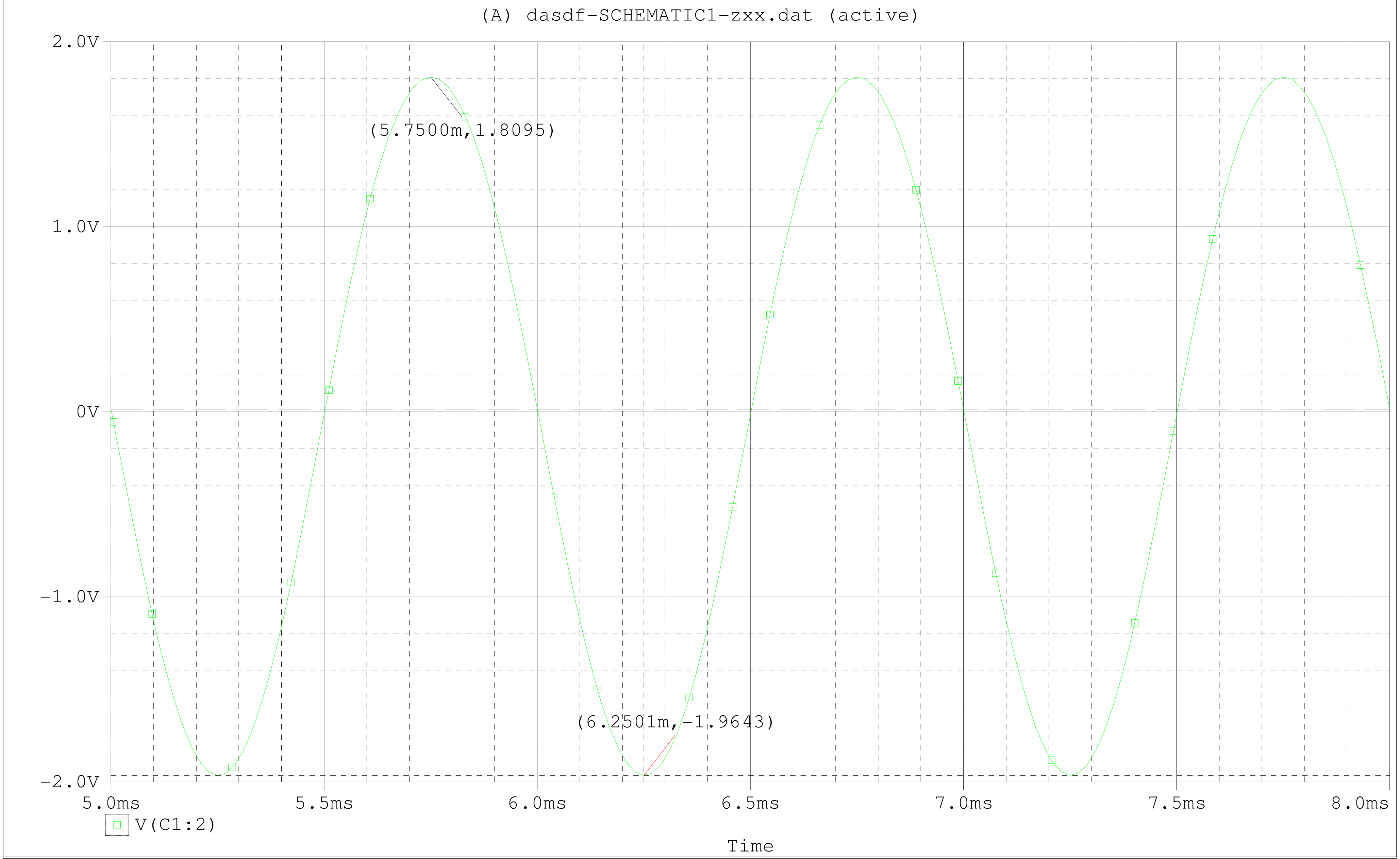

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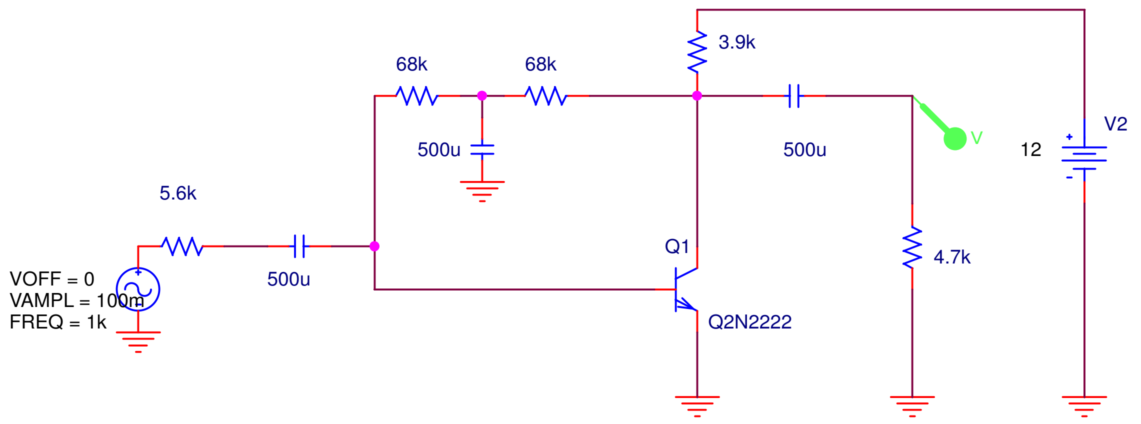
Date: January 09, 2012 Page 1 Time: 00:04:58



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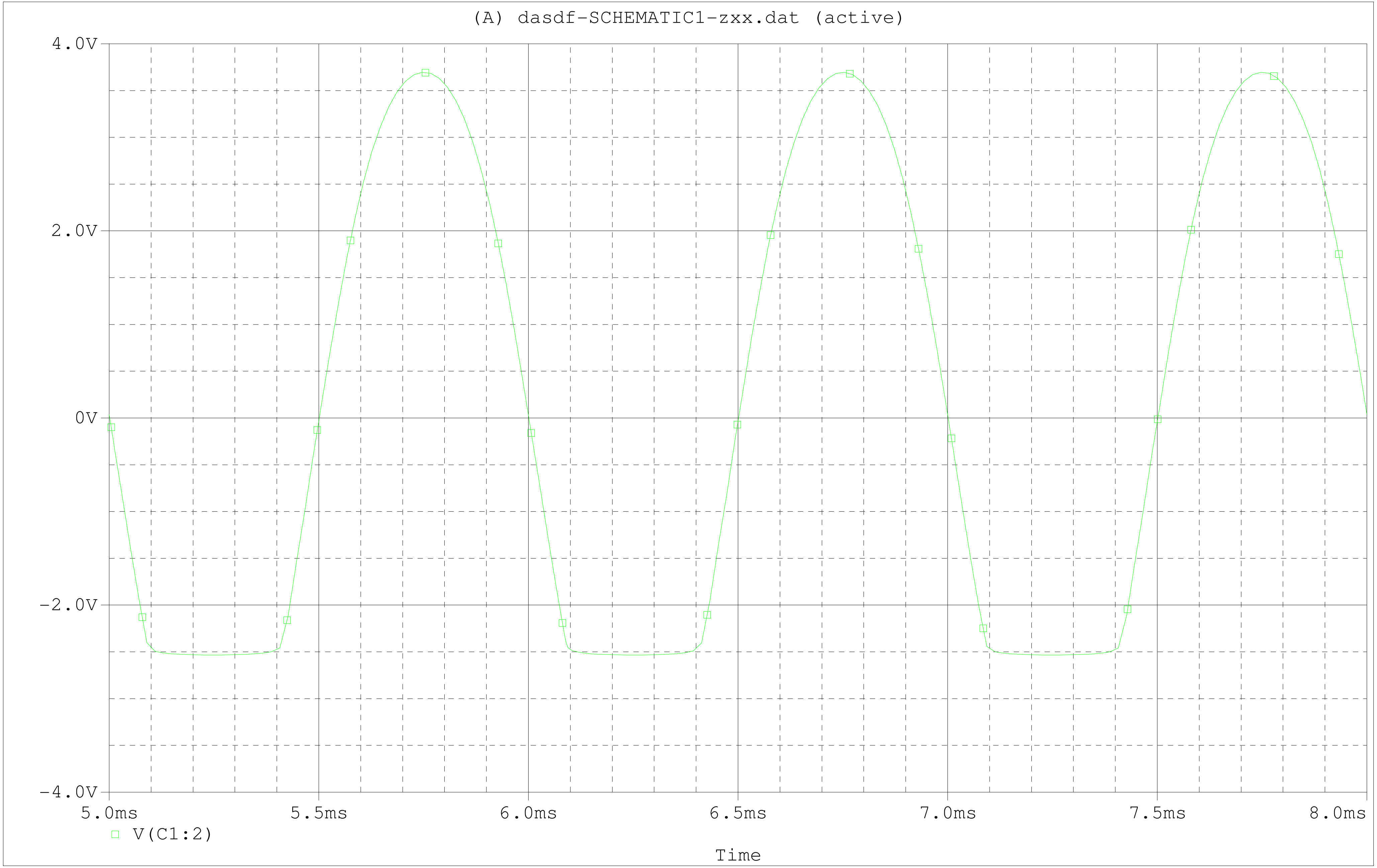

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If we try to increase the input above 42.37 mV we can see how the ouput will be distorted.