EHB 335E HW-4

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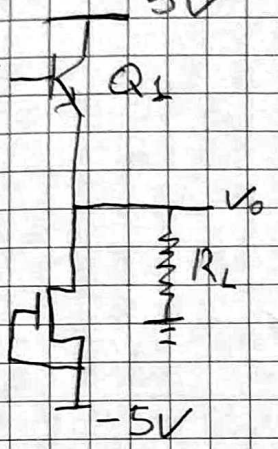
1)



$V_{BE_{on}} = 0,7V$ $\quad V_{CE_{sat}} = 0,2$

$V_A = \infty$ $\quad V_{TH} = -1,8V$ $\quad k_n = 12 mA/V^2$

$\lambda = 0$

$$I_D = k_n (V_{GS} - V_{TH})^2 = \frac{12mA}{V^2} \cdot (0+1,8V)$$

$$= 38.88 mA$$

a.

$R_L = \infty$

$\Rightarrow V_{out_{max}} = 5 - V_{CEsat} = \underline{4,8V}$

going downward

$\Rightarrow V_{out_{min}} = -5 - (V_{GS} - V_{TH}) = \underline{-3,2V}$

Assuming $V_{DSat} = V_{GS} - V_{TH}$ going upwards

$R_L = 500\Omega$

$V_{out_{max}} = 4,8V$ as the former case

$V_{out_{min}} \Rightarrow$ for current trough $R_L \Rightarrow \frac{3,2V}{500} = \underline{6,4mA} < 38.88mA$

Since current required by resistor could be obtained by transistor, minimum voltage is same as former case.

$V_{out_{min}} = -3,2V$

b. $V_{out} = 2V$ $\quad I_{D_{max}} = 38,88 mA$

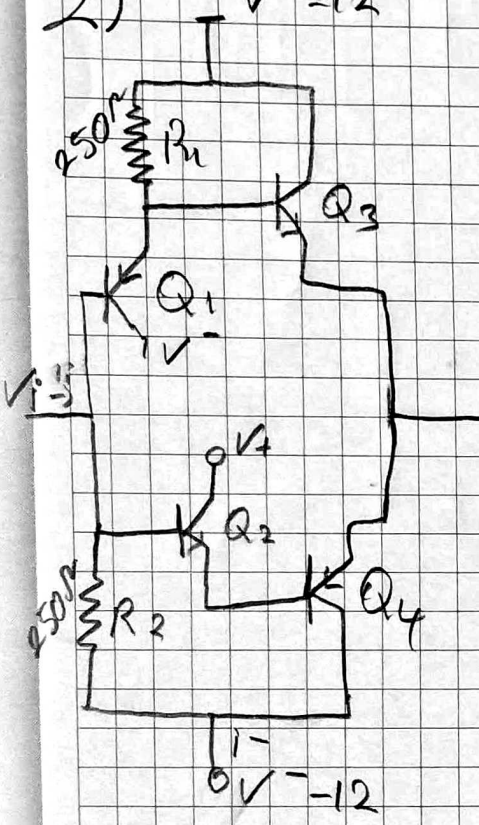
$$R_{L_{min}} = \frac{V_{out}}{I_{D_{max}}} = \frac{2}{38,88} = \underline{51,44\Omega}$$

c. $P_L = \frac{V_o^2}{2R_L\,(RMS)} = \frac{4}{2 \cdot 5 \cdot 1.4} = 38.88\,mW$

$P_{DC} = (5-(-5)) \cdot 38,88 = 388.8\,mW$

power efficiency $\mu = \frac{P_L}{P_{DC}} = \frac{38.88}{388,8} = \%10$ //

2)



$\beta = 40 \quad V_{BE_{npn}} = 0,7 = V_{BE_{pnp}}$

$\underset{12}{V^+} - 250[i_{E_1} + i_{b_3}] - 0,7 = 0$

$\underset{-12}{V^-} + 250[i_{E_2} - i_{b_4}] + 0,7 = 0$

by assuming $i_{E_3} = i_o$, $i_{E_4} = 0$, $i_{b_4} = 0$

$i_{E_2} = 45,2\,mA = \underbrace{[\beta+1]}_{41} \cdot i_{b_2} = i_{b_1}$

$i_{E_1} = i_{E_2} = 45,2\,mA$ //

$i_{b_1} = i_{b_2} = 1,1\,mA$ //

Assuming $I_{R_3} = I_o$

b. $V_{E_2} = 5 - 0,7 = 4,3\,V$ $\quad V_{E_4} = 4,3 - 0,7 = 5V = V_o$

$i_o = \frac{5V}{8} = 0,625A = i_{E_3} = i_{b_3}(\beta+1) \Rightarrow i_{b_3} = 15,2\,mA$

$V_{E_1} = 5 + 0,7 = 5,7V$

$I_{R_1} = \frac{12 - 5,7}{250} = 25,2\,mA = 15,2 + I_{E_1} \Rightarrow I_{E_1} = 10\,mA$

$I_{B_1} = 10\,mA / \beta + 1 = 0,24\,mA$

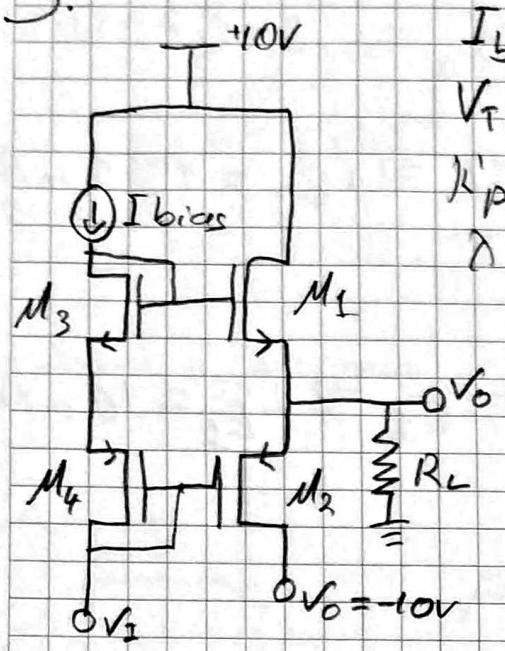
$I_{R_2} = 4,3 - (-12) / 250 = 65,2\,mA = I_{E_2}$

$I_{b_2} = \frac{65,2}{\beta+1} = 1,59\,mA$

$i_{in} = I_{b_2} - I_{b_1} = 1,35\,mA$

C. current gain $= A_i = \frac{i_o}{i_{in}} = \frac{625\,mA}{1,35\,mA} = 462,96$

3.



$I_{bias} = 0,2\,mA \quad R_L = 1k\Omega$

$V_{TH,n} = 0,8V \quad k'_n = 100\mu A/V^2 \quad V_{TH,p} = -0,8V$

$k'_p = 40\mu A/V^2 \quad V_{gs3} = V_{gs4} \quad V_{gs1} = V_{gs2}$

$\lambda = 0$

a. $V_i = -1,5V \quad V_o = 0V$

$V_{gs_2} = 1,5V \quad V_{gs1} = 1,5V$

$I_{D1} = I_{D2} = 0,5\,10^{-3} = \frac{100 \cdot 10^{-6}}{2} \cdot \left(\frac{W}{L}\right)_1 \cdot (1,5-0,8)^2 \Rightarrow \left(\frac{W}{L}\right)_1 = 20,4$

$0,5 \cdot 10^{-3} = \frac{40 \cdot 10^{-6}}{2}\left(\frac{W}{L}\right) \cdot (1,5-0,8)^2 \Rightarrow \left(\frac{W}{L}\right)_2 = 51,02$

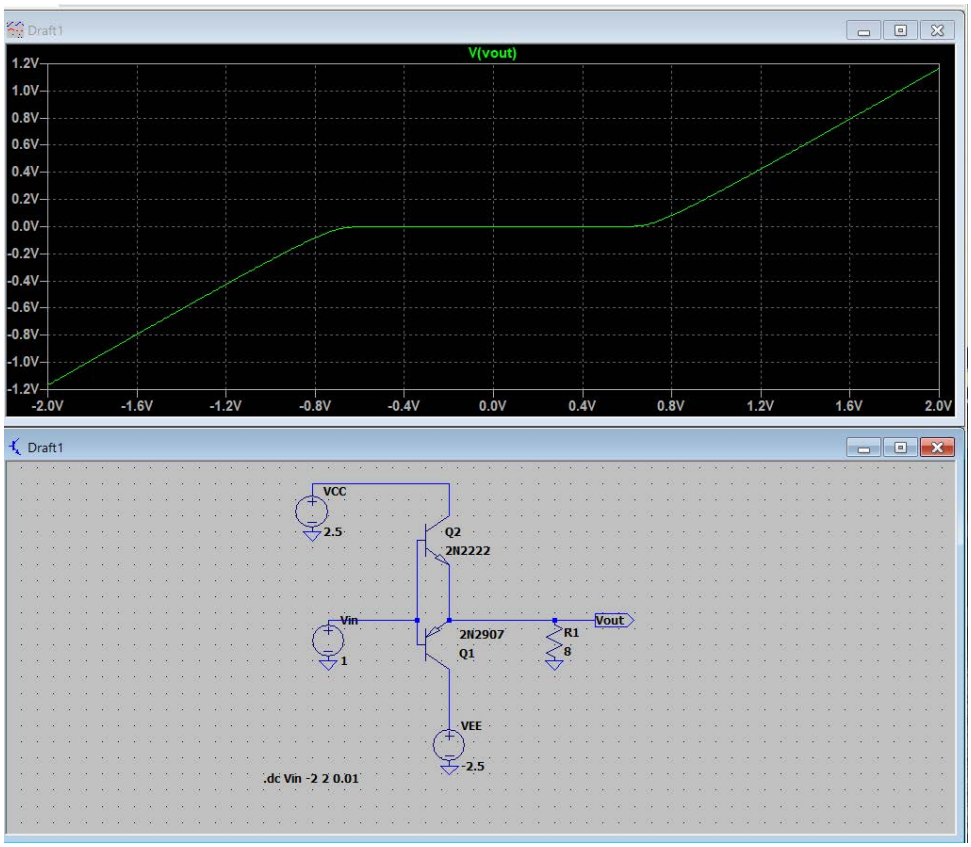
$I_{D3} = 0,2 = \frac{100 \cdot 10^{-6}}{2} \cdot \left(\frac{W}{L}\right)_3 \cdot (1,5-0,8)^2 \Rightarrow \left(\frac{W}{L}\right)_3 = 8,16$

$I_{D4} = 0,2 \quad \frac{40 \cdot 10^{-6}}{2} \cdot \left(\frac{W}{L}\right)_4 \cdot (1,5-0,8)^2 \Rightarrow \left(\frac{W}{L}\right)_4 = 20,4$

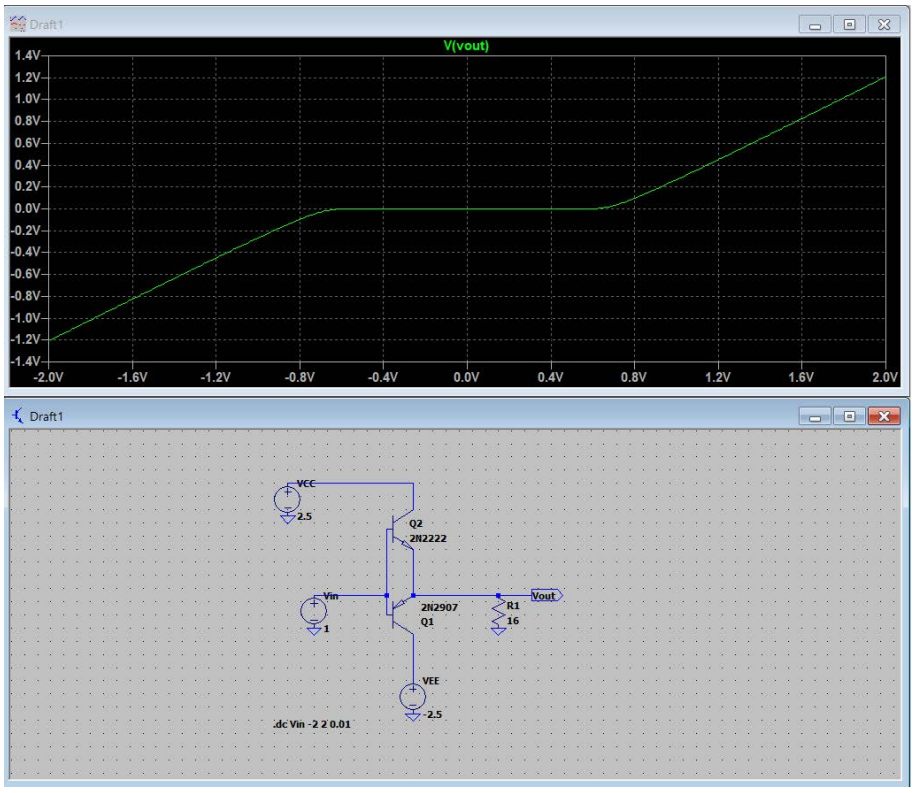
b. $V_{out_{max}} = 10 - V(I_{bias}) - V_{gs1} = 10 - 0,2 - 1,5 = 8,3V$ //

$V_{out_{min}} = -10 - (V_{gs2}) = -10 + 1,5 = -8,5V$ //

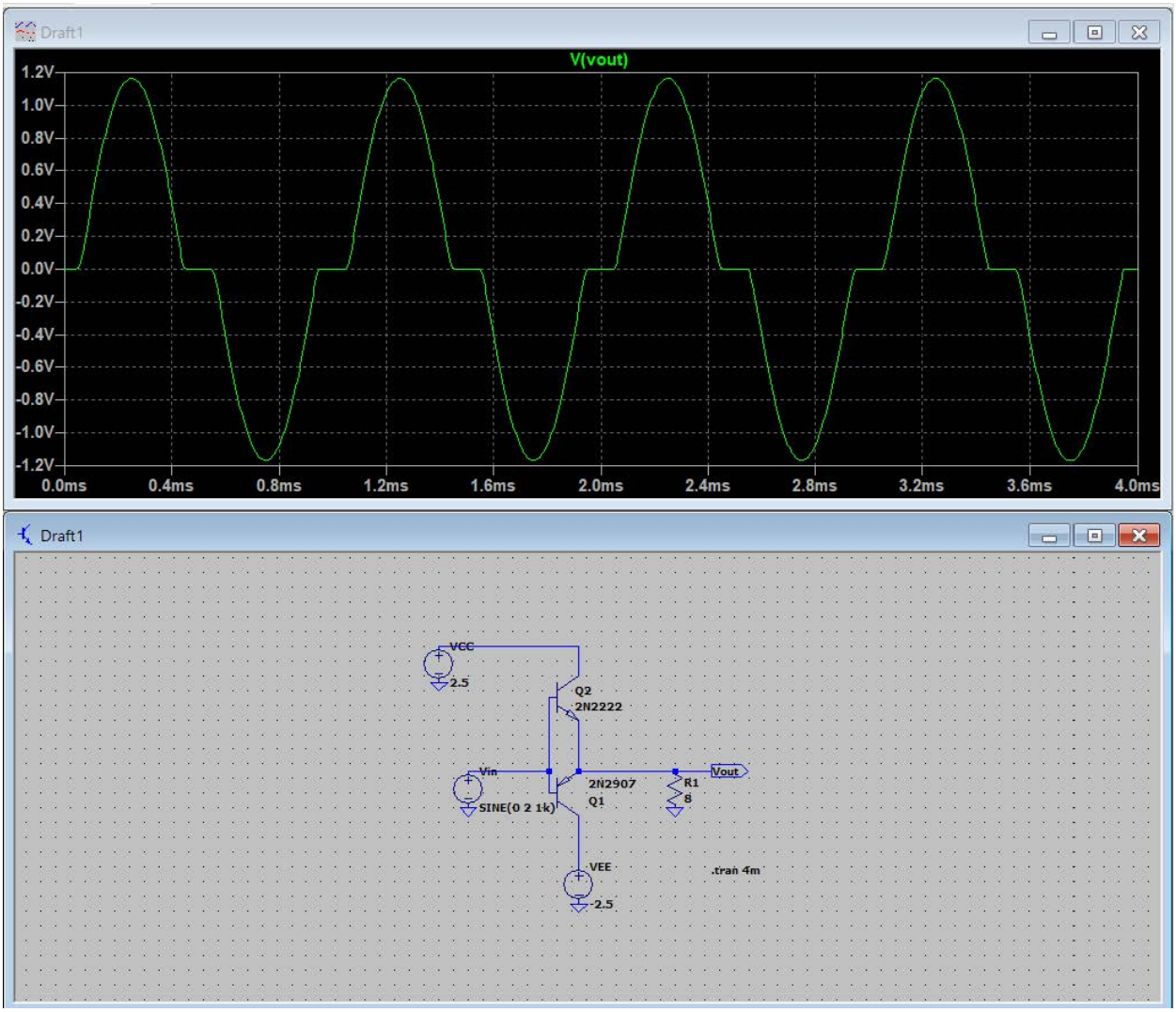
4.a


Draft1
V(vout)
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0.0V
-0.2V
-0.4V
-0.6V
-0.8V
-1.0V
-1.2V
-2.0V
-1.6V
-1.2V
-0.8V
-0.4V
0.0V
0.4V
0.8V
1.2V
1.6V
2.0V
Draft1
VCC
2.5
Q2
2N2222
Vin
1
2N2907
Q1
R1
8
Vout
VEE
-2.5
.dc Vin -2 2 0.01

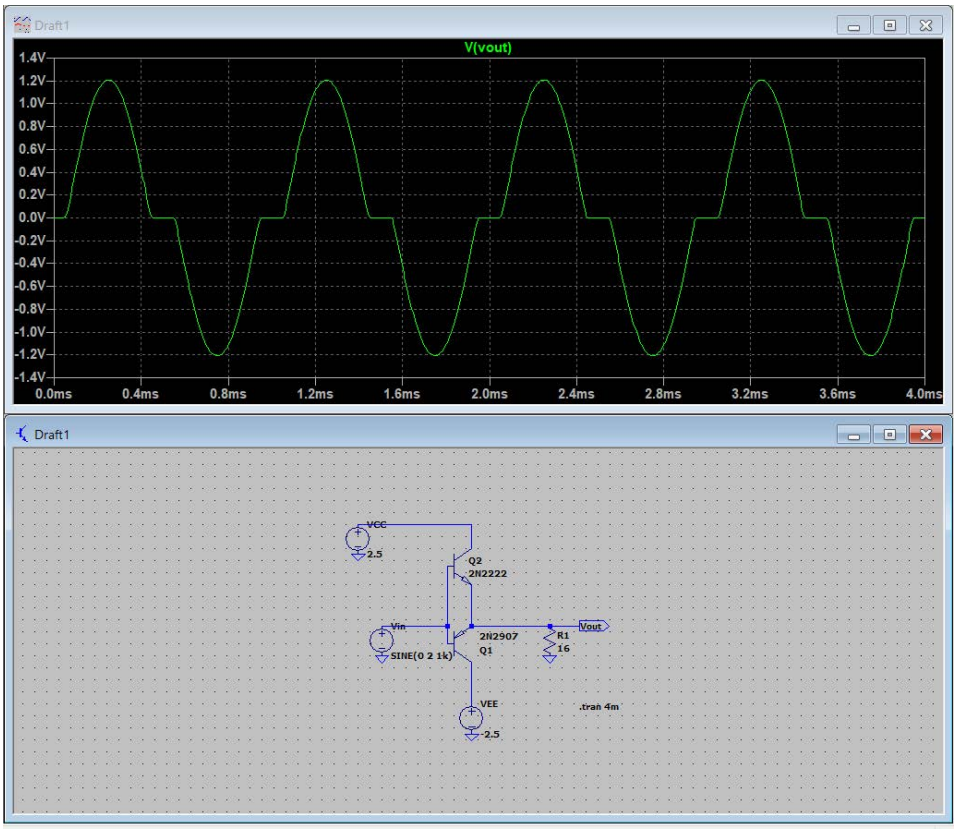
4.b


Draft1
V(vout)
1.4V
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0.0V
-0.2V
-0.4V
-0.6V
-0.8V
-1.0V
-1.2V
-1.4V
-2.0V
-1.6V
-1.2V
-0.8V
-0.4V
0.0V
0.4V
0.8V
1.2V
1.6V
2.0V
Draft1
VCC
2.5
Q2
2N2222
Vin
1
2N2907
Q1
R1
16
Vout
VEE
-2.5
.dc Vin -2 2 0.01

4.c


Draft1
V(vout)
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0.0V
-0.2V
-0.4V
-0.6V
-0.8V
-1.0V
-1.2V
0.0ms
0.4ms
0.8ms
1.2ms
1.6ms
2.0ms
2.4ms
2.8ms
3.2ms
3.6ms
4.0ms
Draft1
VCC
2.5
Q2
2N2222
Vin
SINE(0 2 1k)
2N2907
Q1
Vout
R1
8
VEE
-2.5
.tran 4m

4.d


Draft1
V(vout)
1.4V
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0.0V
-0.2V
-0.4V
-0.6V
-0.8V
-1.0V
-1.2V
-1.4V
0.0ms
0.4ms
0.8ms
1.2ms
1.6ms
2.0ms
2.4ms
2.8ms
3.2ms
3.6ms
4.0ms
Draft1
VCC
2.5
Q2
2N2222
Vin
SINE(0 2 1k)
2N2907
Q1
Vout
R1
16
VEE
-2.5
.tran 4m