

HKN ECE 342 Final Worksheet - Cramming Carnival

DC Analysis

Transistor Parameters

MOSFETs:

$$\mu_n C_{ox} = 100 \mu\text{A}/\text{V}^2; V_{TN} = 1 \text{ V}$$

$$\mu_p C_{ox} = 50 \mu\text{A}/\text{V}^2; |V_{TP}| = 1 \text{ V}$$

BJTs:

$$\beta = 99; V_{BE, \text{on}} = 0.7 \text{ V}$$

Problem 1

For this problem, refer to the circuit below. Use $V_{DD} = 5 \text{ V}$, $I_B = 200 \mu\text{A}$, $1X = \frac{100}{1}$.

figures/cc_dc_2 (1).jpg

- (a) Determine the DC voltages V_1 , V_2 , and V_3 .
- (b) Determine the value of R such that M5 is biased at the edge of saturation.

Problem 2

For this problem, refer to the circuit below.



- (a) Determine the DC currents and voltages V_B , V_E , V_C , I_B , I_E , and I_C of Q1. What is its region of operation?
- (b) Determine the value of R such that M1 is biased at the edge of saturation.

Small-Signal Analysis

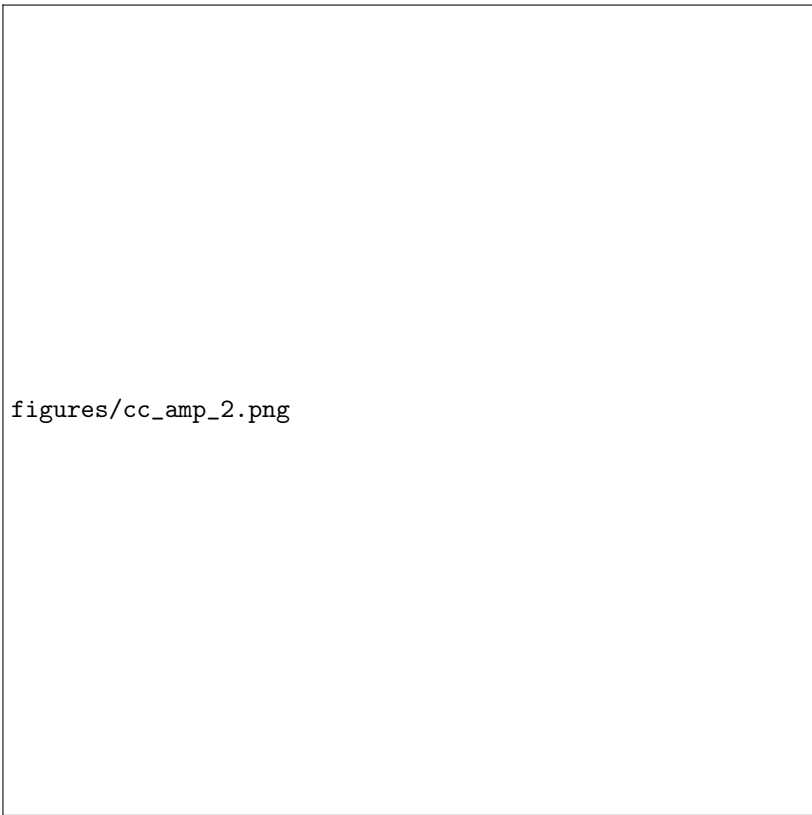
Problem 1

Determine the values of G_M , R_{OUT} , and $A_v = v_{out}/v_{in}$ of this amplifier. Assume all MOSFETs are biased in saturation. Do not assume $r_{ds} = \infty$, though you can assume $g_m r_{ds} \gg 1$.

figures/cc_amp1.png

Problem 2

Determine the values of G_M , R_{OUT} , and $A_v = v_{out}/v_{in}$ of this amplifier. Assume all MOSFETs are biased in saturation, all BJTs are biased in forward active mode, $r_{ds} \neq \infty$, $r_0 = \infty$, and $g_m r_{ds} \gg 1$.



figures/cc_amp_2.png

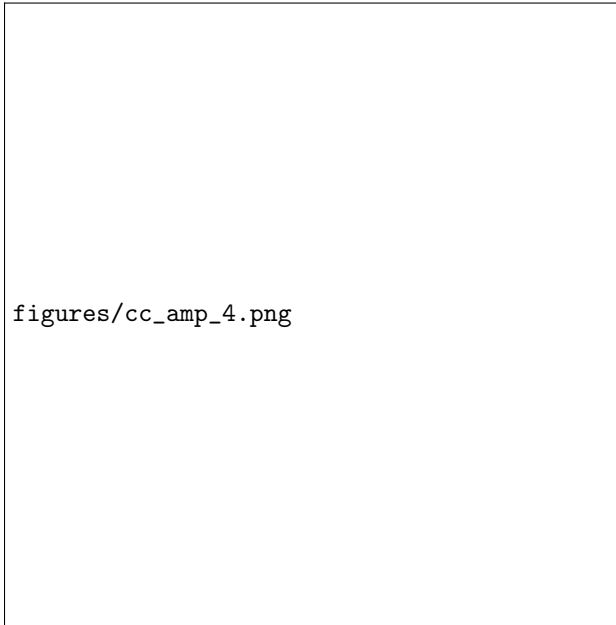
Problem 3

Determine the values of G_M , R_{OUT} , and $A_v = v_{out}/v_{in}$ of this amplifier. Assume all MOSFETs are biased in saturation, all BJTs are biased in forward active mode, $r_{ds} \neq \infty$, $r_0 = \infty$, and $g_m r_{ds} \gg 1$.

figures/cc_amp_3.png

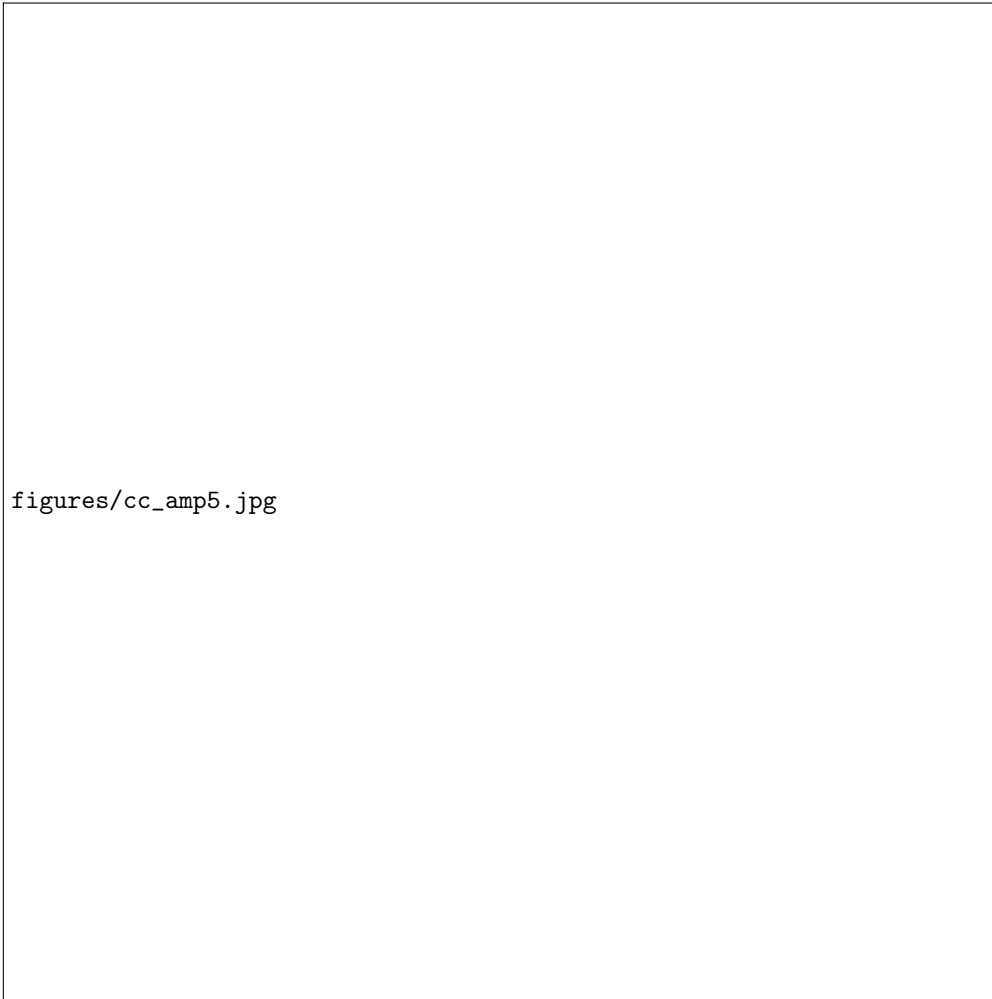
Problem 4

Determine the values of G_M , R_{OUT} , and $A_v = v_{out}/v_{in}$ of this amplifier. Assume all MOSFETs are biased in saturation. Do not assume $r_{ds} = \infty$, though you can assume $g_m r_{ds} \gg 1$.



Problem 5

Determine the values of G_M , R_{OUT} , and $A_v = v_{out}/v_{in}$ of this amplifier. Assume all MOSFETs are biased in saturation, all BJTs are biased in forward active mode, $r_{ds} \neq \infty$, $r_0 = \infty$, and $g_m r_{ds} \gg 1$.



Bode Plots

Problem 1

For the following amplifier transfer functions, **(i)** plot the magnitude response, **(ii)** determine the unity gain frequency, and **(iii)** plot the phase response:

(a)

$$H(s) = \frac{10^4}{s(1 + s/10^3)}$$

(b)

$$H(s) = \frac{2000(1 + s/10^2)}{(1 + s/10)(1 + s/10^3)(1 + s/10^4)}$$

(c)

$$H(s) = \frac{4000(1 + s/10^2)}{(1 + s/10)(1 + s/10^4)^2}$$

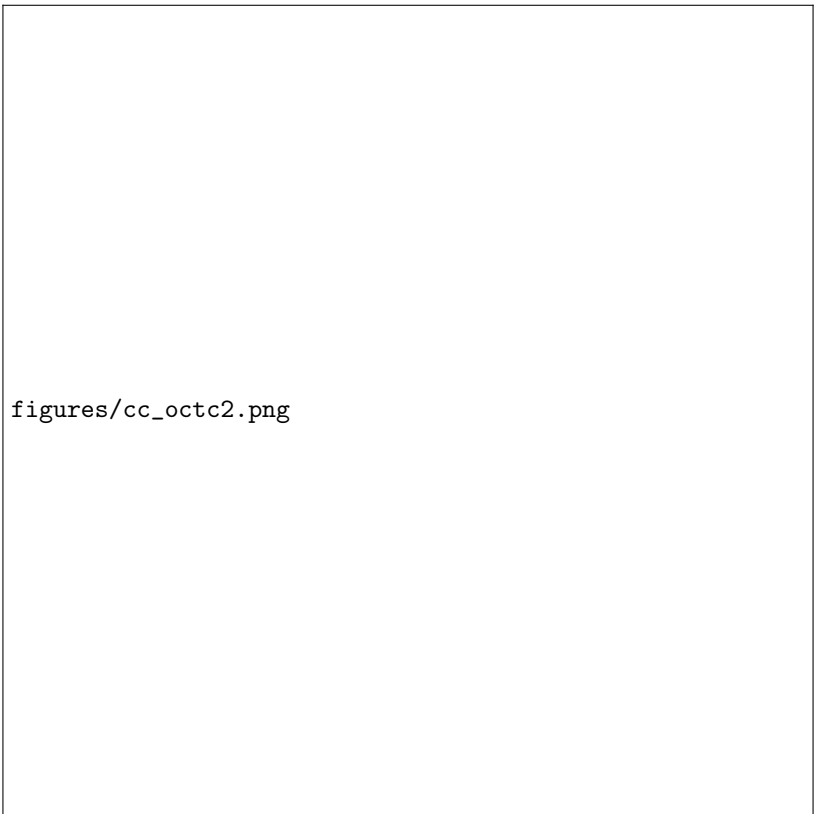
Problem 2

For each of the amplifier transfer functions in Problem 1, determine the incremental output voltage response $v_{out}(t)$ to an incremental input voltage $v_{in}(t) = 10 \cos(10^3 \cdot t)$ mV.

Open Circuit Time Constants

Problem 1

Use the open-circuit time constant method to estimate the -3 dB frequency, $\omega_{-3\text{dB}}$, of this amplifier. Consider C_{gs} , C_{gd} , C_{π} , C_{μ} , and r_{ds} . Ignore r_0 .



figures/cc_octc2.png

Problem 2

Use the open-circuit time constant method to estimate the -3 dB frequency, $\omega_{-3\text{dB}}$, of this amplifier. Consider C_{gs} , C_{gd} , C_{π} , C_{μ} , and r_{ds} . Ignore r_0 .

figures/cc_octc1.jpg

Problem 3

Use the open-circuit time constant method to estimate the -3 dB frequency, $\omega_{-3\text{dB}}$, of this amplifier. Consider C_{gs} , C_{gd} , C_{π} , C_{μ} , and r_{ds} .

figures/cc_octc3 (2).jpg

CMOS Logic Circuits

For each part, design and draw the schematic of a CMOS logic gate that implements the Boolean expression. In each schematic, label the size of each transistor such that the worst case delays of the pull-up and pull-down networks are equivalent to those of a standard minimum-sized inverter with $(W/L)_P/(W/L)_N = 2$. Inverted inputs are not available.

(a) $Z_1 = \overline{(A + B) \cdot C}$

(b) $Z_2 = \overline{(A \cdot B \cdot C) + (D \cdot E)}$

(c) $Z_3 = \overline{A} \cdot (\overline{B} + \overline{C} + \overline{D})$