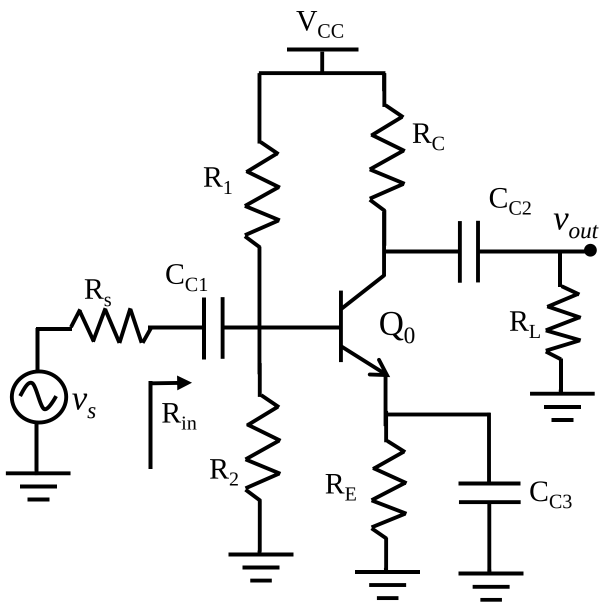
HOMEWORK#4

Please submit your solutions to Moodle by Wednesday, 20.12.2023, 23:55.

1.



Consider the common emitter amplifier shown on the left under the following conditions: R_s=4kΩ, R_1=33kΩ, R_2=22kΩ, R_E=3kΩ R_C=4kΩ, R_L=5kΩ, V_{CC}=5V.

The DC emitter current is found as $V_{BE}(ON)$=0.7V, $V_{CE}(SAT)$=0.2V, β_0=100, and r_o=200kΩ.

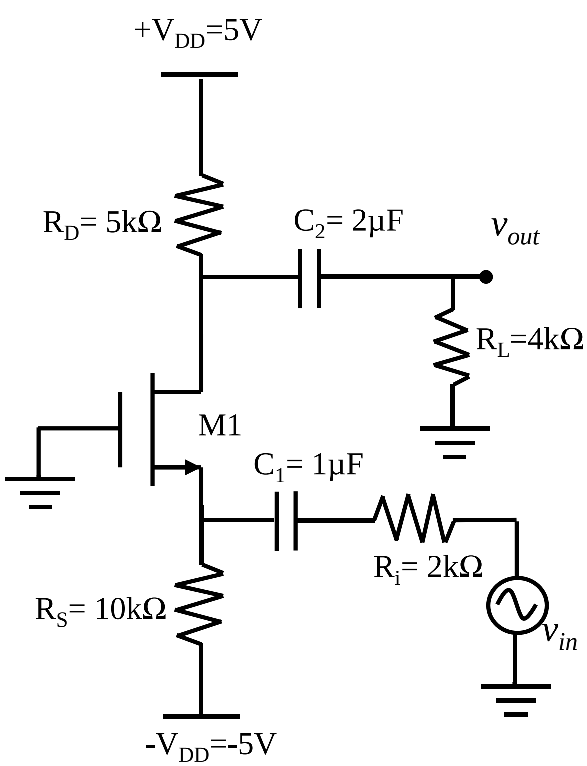
a. Find the DC operating point for Q_0 and verify its state

b. Find the midband input resistance R_{in} and midband gain.

c. If the transistor is specified to have f_T=700MHz and C_μ=1pF, find the upper cutoff frequency.

Since the high frequency response is asked you can assume the external capacitors as short circuit.

2.



The common gate amplifier shown on the left has
V_{TN}=1V
K_N=2mA/V^2
λ=0
C_{gs}=12pF
C_{gd}=3pF

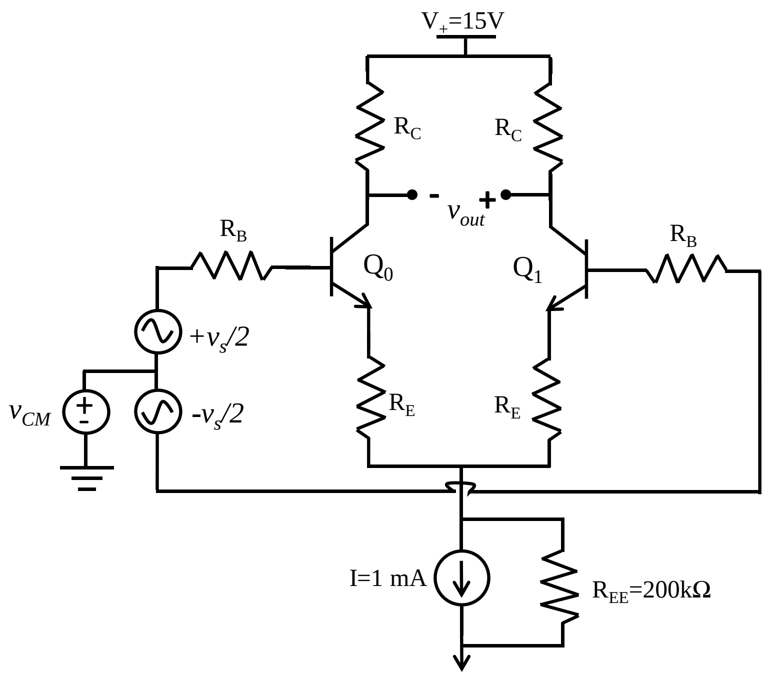
a. Find the DC operating point (I_D,V_{DS}) and verify the state of M1.

b. Fing the midband gain, $A_0 = v_{out} / v_{in}$

c. Find the lower cutoff frequency, f_L

d. Find the upper cutoff frequency, f_H

3.

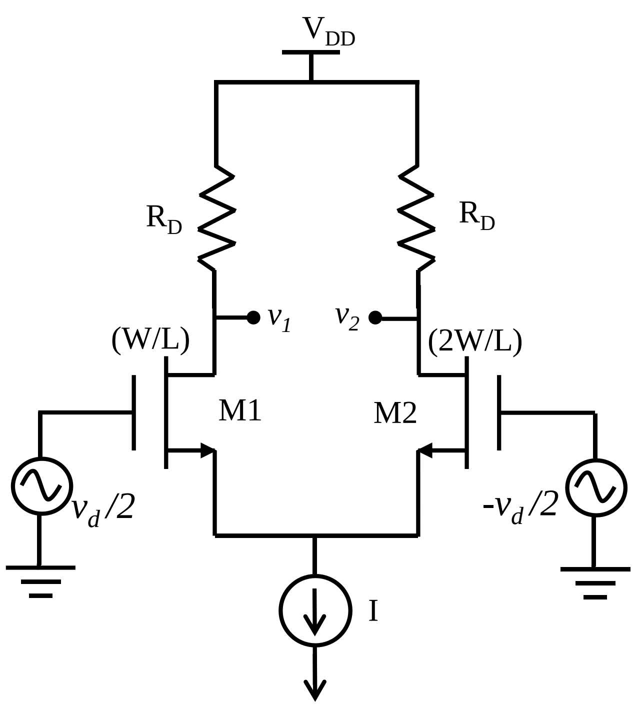


R_C=10kΩ
R_E=150Ω
R_B=5kΩ
β=100
$V_A=\infty$
V_{BE}(ON)=0.7V

v_s and v_{CM} are small signals, find:

- **a.** The input differential resistance R_{id}
- **b.** The overall differential gain $A_{dm}=v_{out}/v_s$
- **c.** The worst-case common mode gain if R_C is accurate to +/-1%
- **d.** The Common Mode Rejection Ratio (CMMR) in dB for the case in c.
- **e.** The input common mode resistance R_{icm}

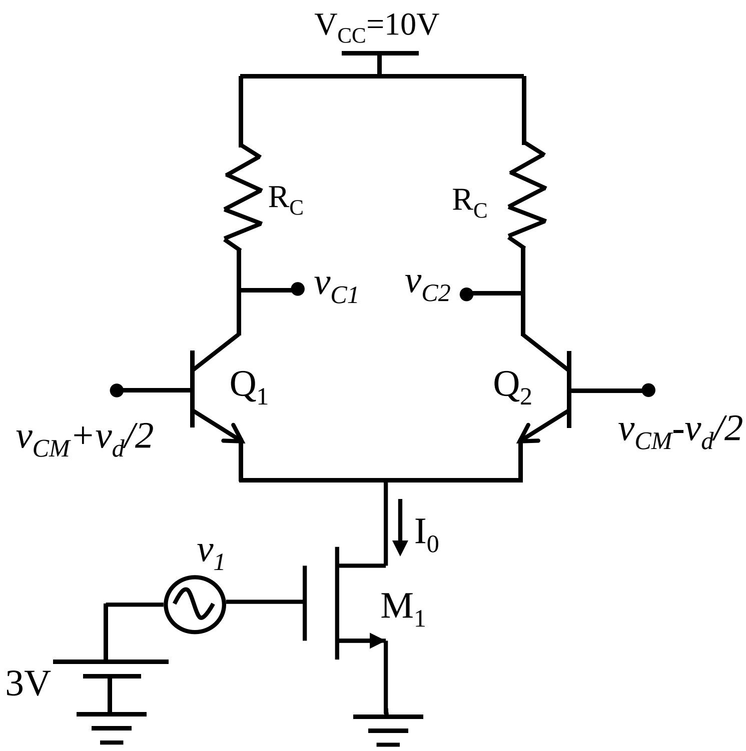
4.



For the MOSFET differential amplifier shown on the left M2 has twice the width of M1. The DC bias on the gate of M1 and M2 are the same.

Find the differential gain of this amplifier in terms of g_{m1} and R_D, i.e $A_{dm}=(v_2-v_1)/vd$. DC analysis is not required. Assume λ=0.

5.



For the circuit shown on the left
β=100, $V_{BE}(ON)$=0.7V,
$V_{CE}(SAT)$=0.2V, V_T=26mV,
K_N=0.5mA/V^2, V_{TN}=1V, R_C=4kΩ
v_1, v_{CM}, v_d are small signals and $v_{CM}=V_{CM}+v_{cm}$

a. Find the range of V_{CM} to keep Q1 and Q2 in F.A and M1 in saturation, $v_1 = v_d = v_{CM} = 0$.

b. v_1=0.1cos(ω_1t) and v_d=0.001cos(ω_2t) and $\omega_2 >> \omega_1$ (v_1 acts like DC compared to v_d). Find $v_{out}=v_{c2}-v_{c1}$ numerically. Comment on the frequency spectrum of v_{out}

c. For v_1=0 and $v_{out}=v_{c2}$ find Common Mode Rejection Ratio (CMMR). λ=0.02 for M1 only for this part.