

Open book open notes but only approved computers; 100 points total (75 minutes)

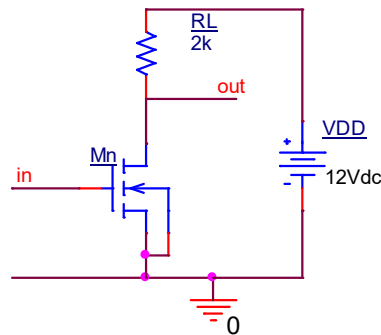
Your signature insures that the work submitted is solely your own. Good luck

For NMOS transistors assume $k=4\text{mA/V}^2 = (K_P/2)(W/L)$, $V_{TO} = 1\text{V}$, $\lambda=0$; for PMOS assume complementary to NMOS except $k=2\text{mA/V}^2$

For bipolar assume $\beta=100$, $V_A=\text{Early voltage} = 200\text{V}$

1. (20 points 10 minutes; NMOS inverter)

For the following circuit determine the input voltage V_{tr} for which when $v_{in} > V_{tr}$ the NMOS transistor is in the triode region.

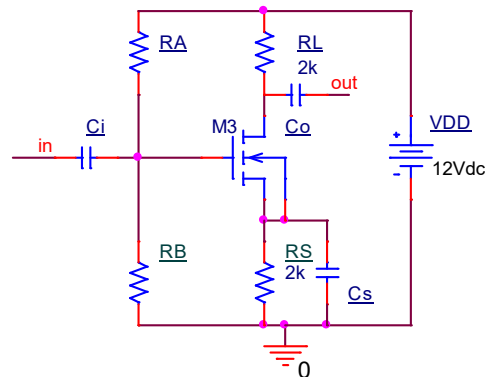


2. (35 points, 20 min; NMOS bias & gain)

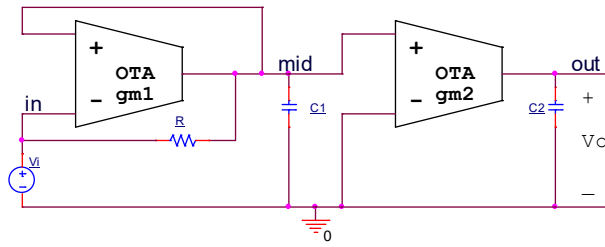
For the following NMOS amplifier assume $R_L=R_S=2\text{k}\Omega$ and R_A need not = R_B (and not necessarily large).

a) For $I_D=1\text{mA}$ find the Q point (bias) values for V_{GS} and V_{DS} and check that the transistor is in saturation

b) Draw the mid-band gain small signal equivalent circuit and give the mid-band voltage gain $A_v = v_{out}/v_{in}$ (where voltages are measured with respect to ground and the capacitors are assumed shorts) [include R_A & R_B].



3. (25 points, 20 min; OTA circuit gain and ODE)



- For this circuit give the voltage transfer function $A_v(s)$.
- Give the differential equation relating $v_o(t)$ to $v_i(t)$

4. (20 points 10 minutes; Small signal parameters)

The FIN-FET is a new transistor being considered for quantum systems. An N-type FIN-FET with n fins has the same circuit symbol and is like an NMOS (with no gate current and bulk tied to source) but has the n -power law (n =number of fins, any positive real n but normally an integer)

Off: $i_D=0$ for $v_{GS}<V_{th}$

And for $v_{GS}\geq V_{th}$:

Saturation: $i_D=k(v_{GS}-V_{th})^{(n)}(1+\lambda v_{DS})$ for $v_{DS}\geq(v_{GS}-V_{th})$

Triode: $i_D=k([2(V_{GS}-V_{th})^{(n/2)}(v_{DS}^{(n/2)})]-v_{DS}^{(n)})(1+\lambda v_{DS})$ for $v_{DS}\leq(v_{GS}-V_{th})$

- Show that there is a number of fins, n , for which the FIN-FET behaves like an NMOS transistor
- For any positive real n , assuming a FIN-FET is biased to be in saturation, find its g_m and g_o in terms of Q point values and draw low frequency equivalent circuit.