HELSINKI UNIVERSITY OF TECHNOLOGY
Electronic Circuit Design Laboratory

S-87.1010 Electronics I / SLi
1. mid-term exam 25.10. 2005
Write your name and student number in each paper.

1. The –3dB frequency of an amplifier is 1MHz and its voltage gain at low frequencies is 100.

a) Sketch amplifier's magnitude and phase responses in the frequency range between 10kHz-100MHz when the frequency response is assumed to have only a single pole.

b) The input refered voltage noise density is $150nV/\sqrt{Hz}$. What is the rms-value of the noise voltage at output?

The source resistance is assumed to be zero (much lower than the input resistance of the amplifier), so that possible current noise has no effect.

2. a) Sketch the i_D-v_{DS} characteristics of an n-channel MOS transistor (NMOS) with the gate-source voltages 1V, 2V and 3V. The threshold voltage V_t of the transistor is 1V and the transconductance coefficienct $k_n'W/L$=1mA/V^2.

b) Indicate the different operating regions in the characteristics. How does the transistor function as a component in the different regions? *A very short description suffices.*

c) How is the drain current I_D affected by the channel length modulation effect? How does the effect show on the i_D-v_{DS} characteristics?

3. In the amplifier of Fig. 1 the bias voltage V_G of the MOS gate is set by resistor R_B=1kΩ, three diodes $D_{1\text{-}3}$ and the supply voltage V_{DD}=10V.

a) Determine the bias voltage V_G and the current I_B flowing through the diodes. Use a constant voltage source V_D=0.7V as a large signal model for a diode.

b) Unfortunately the supply voltage V_{DD} is not perfectly constant but has a small ripple voltage of 100mV coupled to it: $V_{DD} = 10V + 100mV \cdot \sin(\omega_h t)$. Determine the amplitude of the ripple in the bias voltage v_G. by using a small signal equivalent model for the diodes. The thermal voltage V_T=25mV and diodes' n=1.

Hint: If you cannot recall the formula for the diode's dynamic resistance, you can derive it from them i-v relationship: $i_D = I_S\left(e^{v_D/V_t} - 1\right)$.

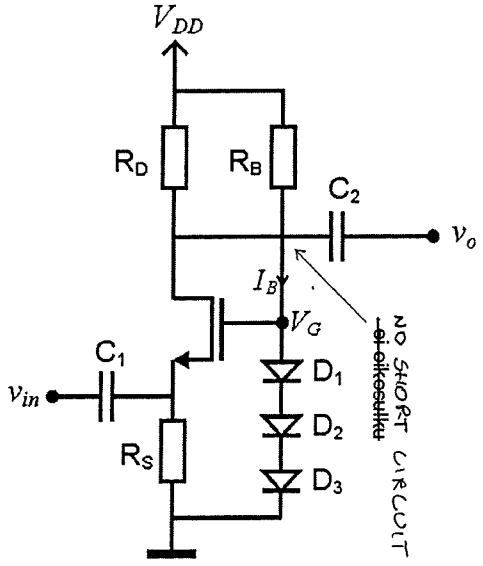

Figure 1.

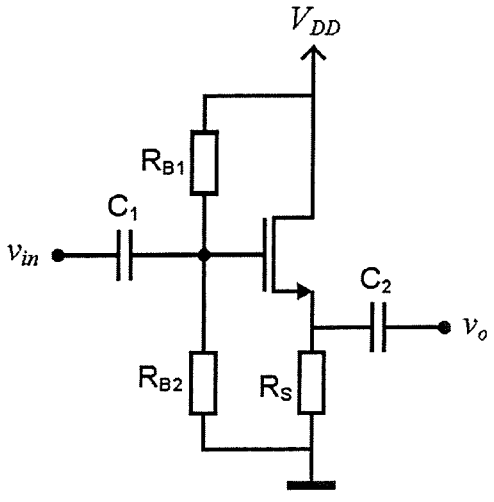

Figure 2.

4. The threshold voltage V_t and the transconductance coefficient $k_n'W/L$ of the MOS transistor in the amplifier of Fig. 2 are 1V and 2mA/V^2, respectively. In addition R_S=2kΩ, R_{B1}=60kΩ, R_{B2}=40kΩ and V_{DD}=10V.

You can neglect the effect of channel length modulation. The capacitors are large with respect to the frequency of interest.

a) Determine the operating point of the transistor.

b) Form a small signal equivalent circuit for the amplifier.

c) Determine the open circuit voltgae gain A_{vo}, short circuit current gain A_{is} and the input and output resistances R_{in} ja R_o.