S-87.2113 Basic electronics Exam 27.09.2009 / Marko Kosunen

Write your name and your student number on every paper (also on possible appendices). All calculators allowed. NO literature allowed.

1. a) Derive an expression for the voltage gain vo/vin of the operational amplifier circuit in Fig. 1.

b) Design the circuit so that its voltage gain is 26dB and its input impedance is $10k\Omega$.

c) The operational amplifier has an input offset voltage $V_{OF} = 10mV$. Calculate the error voltage at the amplifier output.

d) The amplifier is changed so that a capacitor C is connected in series with R_1. How large are the error voltages due to offset voltage and bias current now?

Hint: the sign of V_{OF} is not important.

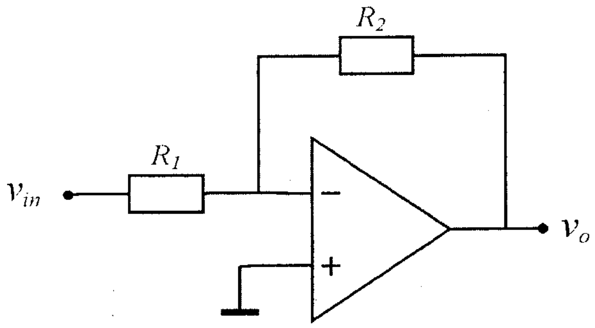

Figure 1:

2 a) Desing the circuit of the figure 2 so that the voltage gain is 10 and the current through the feedback resistor is at most 1mA when the output voltage is 1V. Assume that the operational amplifier is ideal.

b) If the gain of the operational amplifier is not infinite but 80dB, how large is the error due to finite gain in the circuit of a)-part? How large is the error if the overall gain of the circuit should be 200.

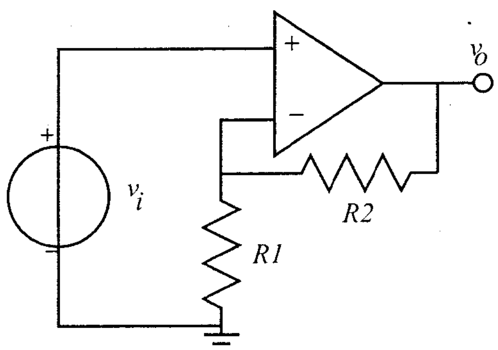

Figure 2:

3. The component values in the amplifier of Fig.3 are as follows: $R_1 = 6k\Omega$, $R_2 = 1k\Omega$, $R_3 = 10k\Omega$, $k_n' \frac{W}{L} = 4mA/V^2$, $V_t = 1V$ and $V_{DD} = 10V$, $i_d = k_n' \frac{W}{2L}(v_{GS} - V_T)^2(1 + \lambda v_{DS})$. You can neglect the channel length modulation of the MOS transistor. Further, the capacitors are big with respect to the frequency of interest.

a) Find the operating point of the transistor.

b) Draw the small signal equivalent circuit of the amplifier.

c) Determine the open circuit voltage gain A_{vo} and the input and output impedances R_{in} and R_o.

d) How much R_1 and R_2 lower the output voltage when the internal source impedance is $1k\Omega$?

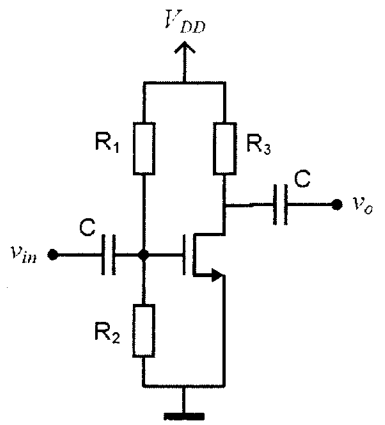

Figure 3:

4. a) Draw the output voltage of the circuit in Fig. 4 in continuous state (not the start-up transient), when the input voltage is $v_i(t) = 1 + 3 \cdot sin(2\pi 1kHz \cdot t)V$ V and the load resistor RL is infinite. Assume that the diode is ideal (no resistance, no forward voltage drop).

b) Draw the output voltage in continuous state when $v_i(t) = 1 + 3 \cdot sin(2\pi 1kHz \cdot t)V$, $R_L = 100k\Omega$, $C_1 = 1\mu F$ and the forward diode voltage is $V_D = 0.7V$. Take the droop at the output into account. (Still neglect the diode's dynamic resistance).

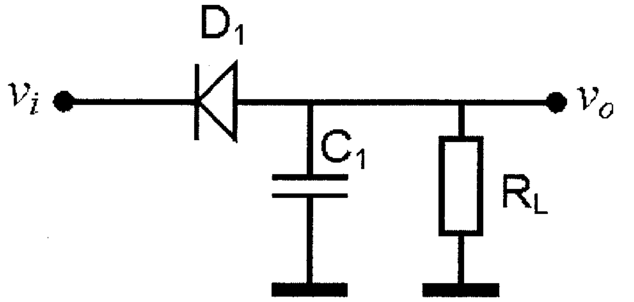

Figure 4: