Oulun yliopisto / *University of Oulu*
Elektroniikan laboratorio / *Electronics laboratory*

Elektroniikkasuunnittelun perusteet (Principles of electronic design 521431A)
Exam 16.12.2005

1. a) Calculate amplification and lower corner frequency of the circuit shown in fig 1 a).
   b) Design using an operation amplifier a circuit, which has:
   R_{in} = 1 kΩ and amplification A = -20.
   c) Draw the output signal u_O vs. time of the circuit shown in fig 1 b) in a same figure with the input signal u_i.

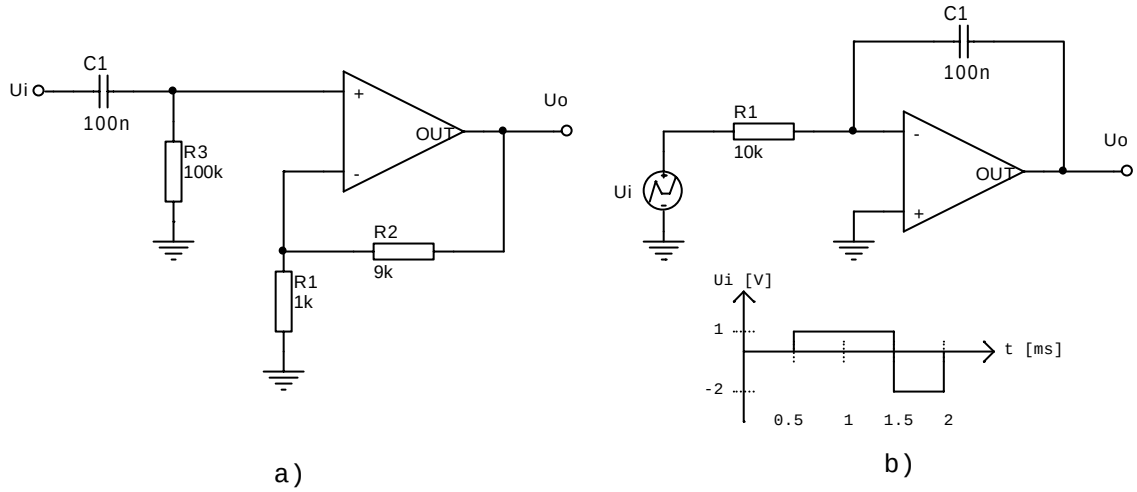

Fig 1.

2. Design a circuit using diodes, resistors and DC-voltage sources, which limits the input signal in fig 2. to level +4V / -5V. (voltage across forward-biased diode is 0.7V)

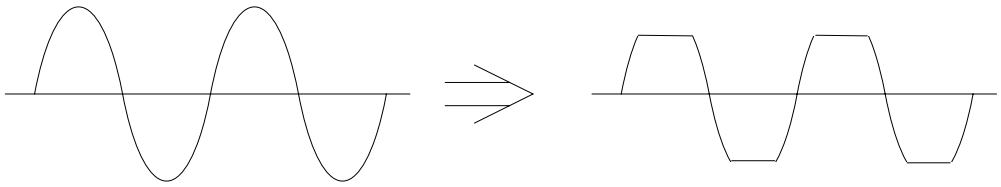

Fig 2.

3. Calculate following parameters from the circuit shown in Fig 3.
   a) I_C, U_C, U_B and U_E (DC-values)
   b) u_o/u_i, R_{in} and R_{out} (you can assume β>>, but when calculating R_{in} use β=100)
   BONUS: Draw u_C ja u_O (total signals) to same figure vs. time.

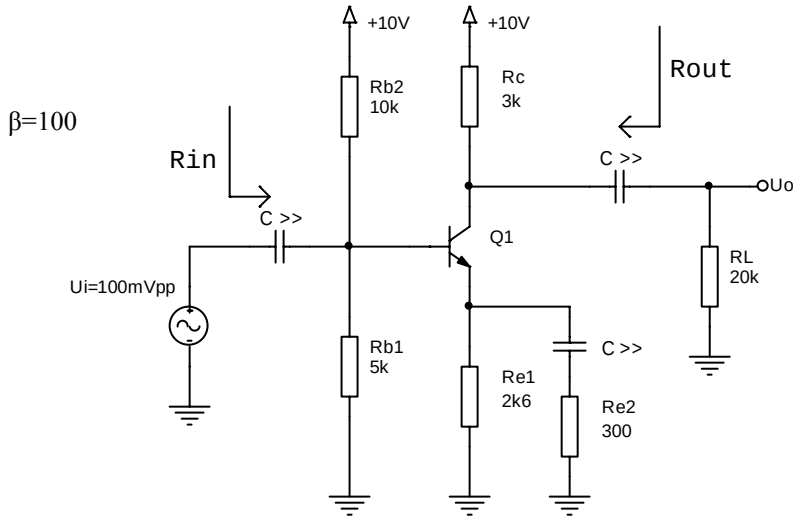

Fig 3.

4. a) Design and draw 2-input NAND-gate using 0.35μm:n CMOS-technology.
   (design = choose W and L for transistors and explain your choice.)
   b) What would be the switching threshold voltage, if V_{DD} = 3V?
   c) How much is the propagation delay (to the level 50%) when C_L = 10 pF?

$U_{tn} = U_{tn} = 0.8$ V
$\mu_n C_{ox} = 100\ \mu AV^{-2}$
$\mu_p C_{ox} = 50\ \mu AV^{-2}$

$$r_{ds} \approx \frac{1}{\mu_n C_{ox}\left(\frac{W}{L}\right)(u_{GS} - U_t)}$$

$$t_d \approx 0.7 \cdot RC$$