University of Oulu
Department of Electrical and Information Engineering, Electronics Laboratory

Principles of Electronics Design 521431A
Exam 18/12/2009

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1. Draw on a same scale the output and input voltages of the circuit of Fig. 1 in case when current I = 1 mA. The diode is a normal small-signal diode, capacitances are very large, $R_s = 100\,\Omega$ and v_s is an ac-signal with the amplitude of 10 mV and the frequency is such that capacitances can be considered as short-circuits. How does the output change if I is changed to 100 μA? Can you imagine any use for this circuit?

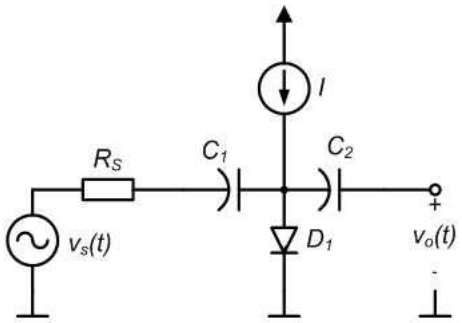

Figure 1: Figure for question 1.

2. An npn-transistor ($\beta >>$) amplifier stage is shown in Figure 2.

   (a) How is it called?

   (b) Dimension the dc-operating point of the amplifier stage so that voltage drop over collector resistance R_C is $V_{CC}/3$ and voltage drop between collector and emitter is $V_{CE} = V_{CC}/3$. The emitter current of the transistor stage should be $I_E = 1$ mA and input impedance between 1 kΩ − 10 kΩ.

   (c) Dimension the open loop ($R_S = 0\,\Omega$ and $R_L >>$) voltage gain $v_{out}/v_{in} = -10V/V$.

   (d) What are the input and ouput impedance values of the transistor stage?

   Capacitance values (C_B, C_C and C_E) are very large.

3. In the op amp circuit of Fig. 3 $R_1 = R_3 = 1\,\text{k}\Omega$ and $R_2 = R_4 = 100\,\text{k}\Omega$

   (a) What is the amplification for input signal and the amplitude of the output signal if $u_{in} = 0.01sin(2\pi 1\,\text{kHz} \cdot t)$ V? (2p)

   (b) What is the dc-level at the output? (1p)

   (c) What is the input impedance of the circuit? (1p)

   (d) You want to limit the bandwidth of the circuit to about 16 kHz so that the signal u_{in} at 1 kHz and lower frequencies are not attenuated. How do you modify the circuit? (1p)

   (e) What is the transfer function $\frac{u_{out}}{u_{in}}$ of the circuit after the change you made? Please provide a symbolic solution in the s-plane. (1p)

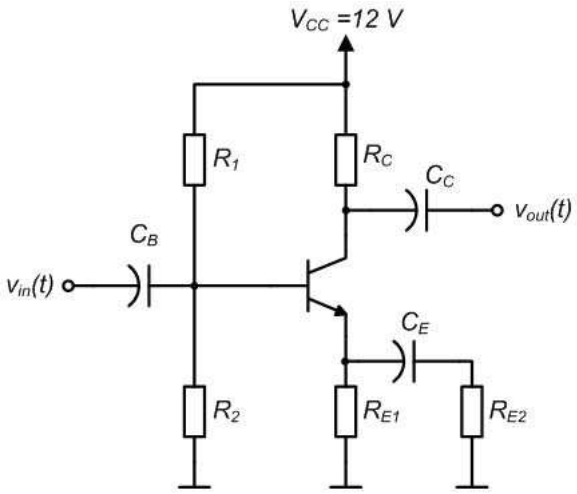

Figure 2: Figure for question 2.

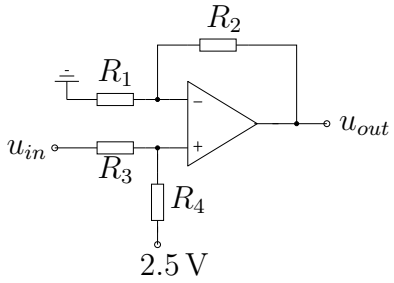

Figure 3: Figure for question 3.

4. Find the input and output impedance of the MOSFET amplifier shown in figure 4? Find the value of R_1 and W/L ratio so that the gain $u_L/u_{src} > 10$. Transistor parameters: $\mu_n C_{ox} = 25\,\mu\text{A}/\,\text{V}^2$, $\lambda = 0$ and $U_t = 2\,\text{V}$. Capacitors C_1, C_2 and C_3 are large coupling capacitors. (6p)

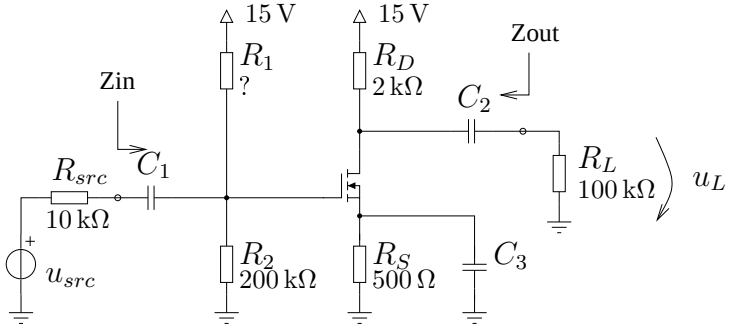

Figure 4: Figure for question 4.

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\begin{aligned}
i_D &= \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(u_{GS}-U_t)^2(1+\lambda\cdot u_{DS}) \\
g_m &= \frac{\partial i_D}{\partial u_{GS}}|_{u_{GS}=U_{GS}} = \mu_n C_{ox}\frac{W}{L}(U_{GS}-U_t)
\end{aligned}
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