Written exam at the course

ELEMENTS of SEMICONDUCTOR ELECTRONICS
(ELEMENTI POLPREVODNIŠKE ELEKTRONIKE)

Ist Bologna grade – 2nd year – Electronics – AE

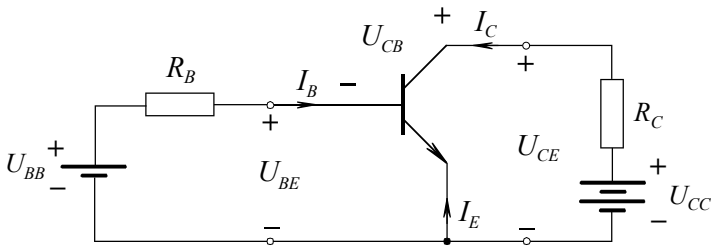
30. 1. 2015

1. Determine semiconductor type for a sample/piece of crystalline Si which contains homogeneously distributed donor impurities at a concentration of $1{,}5\times10^{17}$ cm^{-3}. Calculate the energy difference (in eV) between the actual and intrinsic Fermi level at a temperature of 340 K and sketch energy band diagram. Calculate the specific conductivity of the sample.
   (Data: $n_i = 2{,}5 \times 10^{11}$ cm^{-3}, $\mu_n = 800$ cm^2(Vs)$^{-1}$, $\mu_p = 320$ cm^2(Vs)$^{-1}$)
   (Solution: **n-type**, $U_T = 29{,}33$ mV; $\boldsymbol{E_F - E_{Fi} = 0{,}390}$ **eV**; $\boldsymbol{\sigma = 19{,}2}$ **S/cm**)

2. For the diode with a quality factor of $n = 1{,}9$ at room temperature we measured the following two points of the characteristic:
   - $I_1 = 1$ mA at $U_1 = 0{,}62$ V
   - $I_2 = 50$ mA at $U_2 = 0{,}89$ V

   Calculate the diode's saturation current, disregarding the influence of the internal resistance in the first point. Afterwards calculate the internal resistance.
   (Solution: $\boldsymbol{I_S = 3}$ **nA**; $U_{D2} = 0{,}811$ V; $\boldsymbol{R_S = 1{,}86}$ **Ω**)

3. In the given circuit with a bipolar transistor determine the base resistance R_B so that the voltage on the collector resistor R_C equals $U_{CC}/2$. In which range the transistor operates (explain why)?
   (Data: $\alpha_F = 0{,}99$, $U_{BB} = 5$ V, $U_{CC} = 12$ V, $R_C = 2{,}2$ kΩ, $U_{BE} \approx 0{,}7$ V).



   (Solution: $I_C = 2{,}73$ mA; $\beta = 99$; $I_B = 27{,}6$ μA; $\boldsymbol{R_B = 156}$ **kΩ**; $U_{CB} > 0$ => **active range**)

4. For a MOS transistor with an induced n-channel, which operates in the point $U_{GS} = 5$ V, $U_{DS} = 5$ V, in common source orientation, determine the operating range (under-saturation or saturation) and incremental conduction quadripole parameters g_{ij}. Draw a replacement model of the transistor for small low-frequency signals in the given operating range (model with g parameters).
   (Data: $C_0\mu_n = 1$ mA/V^2, $W/L = 0{,}8$, $U_T = 1{,}2$ V)
   (Solution: **saturation**; $\boldsymbol{g_{11} = 0}$; $\boldsymbol{g_{12} = 0}$; $\boldsymbol{g_{21} = 3{,}04}$ **mS**; $\boldsymbol{g_{22} = 0}$)

You have 60 minutes, you are allowed to use the sheet with basic formulas and constants.
The results are expected to be published on Monday morning in the STUDIS.