TÉCNICO LISBOA

Exam of Fundamentos de Electrónica

8th January 2014

Exam lasts for 3 hours. Justify every question.

1 (2+2+1); 2 (3); 3 (2+1,5+0,5); 4 (2+1,5+1,5); 5 (1,5); 6(1+0,5).

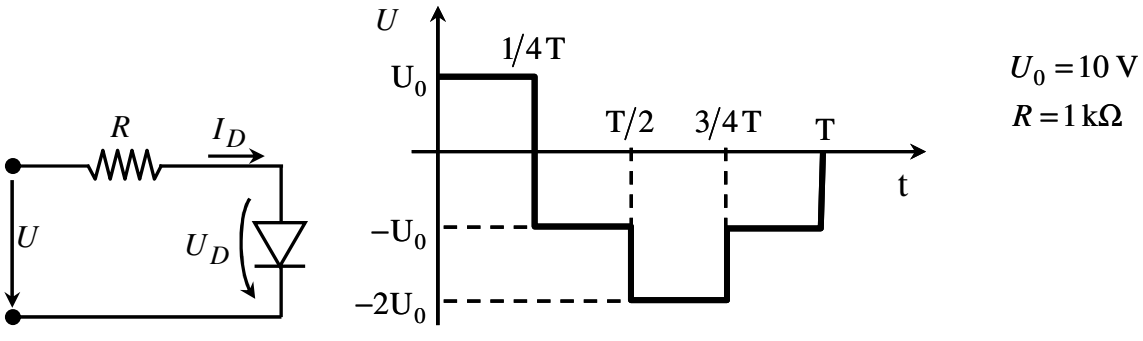
1. Consider two resistors in parallel R_A e R_B. They are of the same material, which at 300 K has the following characteristics: $W_G = 1{,}1$ eV; $\mu_n = 0{,}15\ m^2\,V^{-1}\,s^{-1}$; $\mu_p = 0{,}05\ m^2\,V^{-1}\,s^{-1}$ and $n_i = 10^{16} m^{-3}$. The 2 resistors have equal dimensions, one of them being intrinsic and the other *n*-type extrinsic. At 300K the relationship between the current in the 2 resistors is given by $I_{RA}/I_{RB} = 0{,}001$.

   a) Identify the extrinsic resistor and calculate its donor density, assuming that at 300 K every impurity atom is ionized.

   b) Calculate I_{RA}/I_{RB} at 350K, assuming that in that range of temperature the electron and hole mobilities vary according to $T^{-3/2}$. If the temperature goes on increasing, what would be the limit for this relationship?

   c) Assume that the extrinsic resistor is illuminated by a radiation associated with a rate G_{fe} with $G_{fe}/G_{ter}=9$. Calculate the value of hole concentration in the stationary situation with illumination.

2. Consider circuit of Fig.1, where D is a Ge diode that at 300 K presents the following characteristics : $I_{is}=10\mu A$; $U_{Ddisr} = -15V$, $\eta=1$.



(a) (b)

Fig. 1

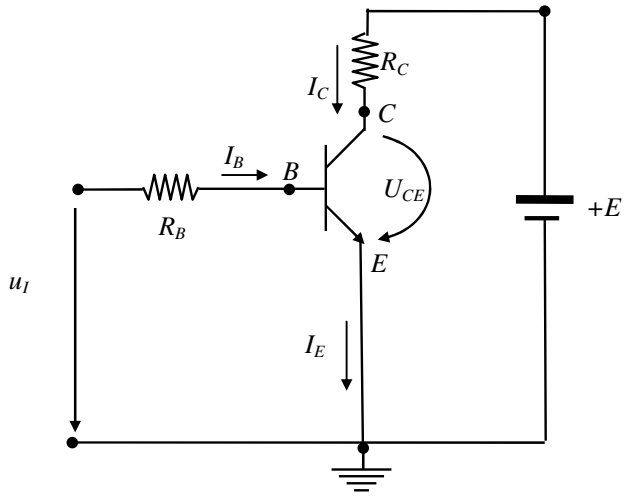
Assume that the input voltage U has the time dependence represented in Fig.1b). Using the almost stationary regime, represent graphically a period of $I_D(t)$ at 300K, calculating the maximum value for the dissipated power in the diode during this range of time.

3. Consider circuit of Fig.2, where: R_B=50 kΩ; R_C=0,5 kΩ, E=15 V; β_F=100, I_{CE0}=1 μA. Neglect the voltage across the transistor junctions when these are forward biased.

   a) Calculate the DC and the variable components of $U_{CE}(t)$ when the input voltage is given by $u_I(t) = 5+5\times10^{-3}\cos\omega t$ V. Assume that for the frequency of the input signal the capacitive effects associated to the transistor are negligible.

   b) Draw a period of $U_{CE}(t)$ when $u_I(t)$ is a triangle shape voltage with a peak-to-peak 20V and average null value. In the graphic, identify all operating zones for the BJT.

   c) Assume that u_I = 5V and that the transístor is submitted to a a radiation associated to a illumination current I_{Cilum}=10 mA. Calculate the voltage between collector and base, U_{CB}, when the base circuit is interrupted (I_B=0).



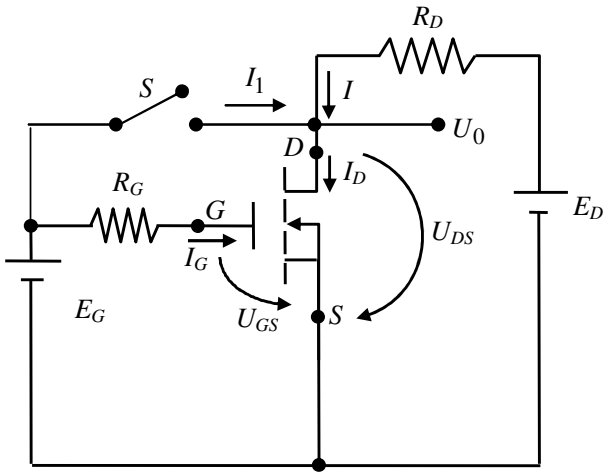
- Fig. 2 –

4. Consider the circuit of Fig.3 with a *n*- MOSFET of enhancement type that presents at 300 K the following features: U_{GSlim}=V_T=1V and A =2 mA/V^2. Data: R_D=1 kΩ e R_G=100kΩ.

   a) Calculate E_G and E_D when the switch S is open and the quiescent point is in the frontier saturation/triode with I_D = 4 mA.

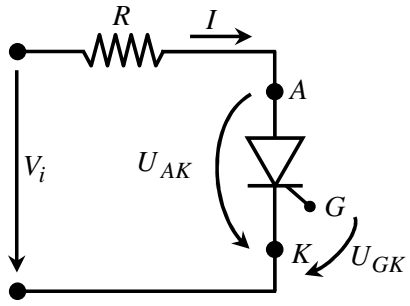
   b) Assume that E_G and E_D have the values calculated in a) when the switch S is closed. Calculate U_{GS}, U_{DS}, I and I_D. In case you have not solved a), consider E_G = 5V e E_D=10V.

   c) Assume that in the conditions of b) an alternate sinusoidal signal of small amplitude and frequency e_g=E_{GM} senωt is placed in series with E_G. Draw the incremental circuit and calculate the incremental voltage gain u_0/e_g , where u_0 is the variable part of voltage U_0.



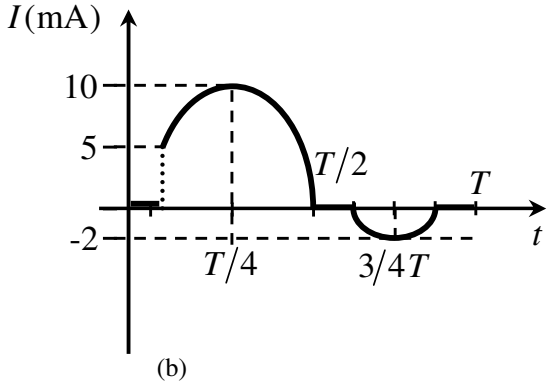
– Fig.3 –

5. Consider circuit of Fig.4a), where $Vi(t)$=100 sen ωt V with f=50 Hz. The current in the circuit The current, represented in Fig.4b), is formed by arcs of harmonic functions. Represent graphically the thyristor stationary characteristic current-voltage $I(U_{AK})$, calculating all its characteristic points. In the circuit R=10 kΩ.



(a)

Fig. 4



(b)

6. Consider the n-n hetero junction formed by $Al_xGa_{1-x}As$/GaAs with x=0,1.
Data: $W_G(x)$=1,424+1,247x eV; $\chi(x)$= 4,07-1,1x eV.

   a) Calculate the relationship between the impurity densities in the binary and the ternary compounds, in order that the flat band condition is attained (no potential contact). Assume that the effective densities in the conduction bands are the same in both semiconductors

   b) Calculate the maximum wavelength of the emitted radiation by the ternary.