Universidade Federal do Rio de Janeiro
Escola Politécnica

DATA: 10/7/2018

GRAUS

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Aluno(a): Prova Final — Gabarito

Disciplina: Eletrônica I — EEL315

Turma: 2018/1

Professor(a): José Gabriel

Questão 1

$N_A = 10^{16} \longrightarrow \boxed{p = 10^{16}/cm^3}$

$np = n_i^2 \longrightarrow n = (1.08 \times 10^{10})^2/10^{16} \longrightarrow \boxed{n = 1.17 \times 10^4/cm^3}$

$E = 5/(0.5 \times 10^{-6}) = 10^7\ V/m = 10^5\ V/cm$

$J = 1.6 \times 10^{-19}(\cancel{1350 \times 1.17 \times 10^4} + 480 \times 10^{16}) \times 10^5 = 480 \times 1.6 \times 10^2 = 7.68 \times 10^4\ A/cm^2$

$A = (50 \times 10^{-7})^2 = 2.5 \times 10^{-11}\ cm^2$

Então $I = 7.68 \times 2.5 \times 10^{-7} \longrightarrow \boxed{I = 1.92\,\mu A}$

Questão 2

$V_0 = \frac{kT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right) = 26 \times 10^{-3} \ln\left(\frac{10^{34}}{1.17 \times 10^{20}}\right) = 26 \times 10^{-3} \underbrace{\ln(8.547 \times 10^{13})}_{32.08} = \boxed{834\ mV}$

Questão 3

Chute inicial: $V_D = 0.6\ V$

Então: $I_D = 10^{-15} \exp(V_D/(26\ mV)) \longrightarrow I_D = 10.5\,\mu A$

$V_D = 0.5 - 2200\, I_D \longrightarrow V_D = 0.477\ V$

$I_D = 10^{-15} \exp(V_D/0.026) \longrightarrow I_D = 92.8\ nA$

$V_D = 0.5 - 2200\, I_D \longrightarrow V_D = 0.5\ V$

$I_D = 10^{-15} \exp(V_D/0.026) \longrightarrow \boxed{I_D = 225\ nA}$

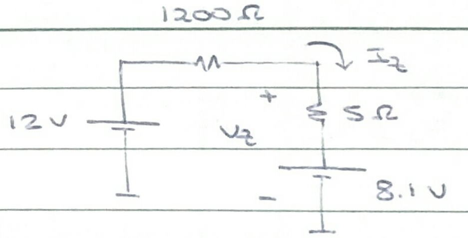
$V_D = 0.5 - 2200\, I_D \longrightarrow \boxed{V_D = 0.5V}$ (exato: 0.4995 V)

Questão 4

Para corrente em torno de $(12 - 8.2)/1200 = 32\ mA$, vamos usar o seguinte modelo: $V_{Z0} = 8.1\ V$: $8.1\ V$ —— "0 mA"

$8.2\ V$ —— $20\ mA$

$r_Z = \Delta V_Z / \Delta I_Z = 0.1/0.02 \longrightarrow r_Z = 5\,\Omega$



$I_Z = (12 - 8.1)/1205 \longrightarrow \boxed{I_Z = 3.2\ mA}$

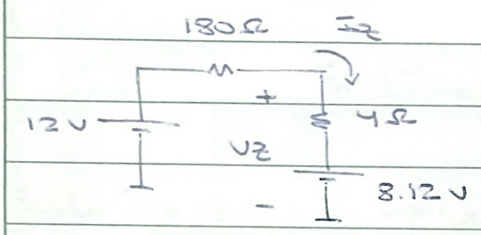
$V_Z = 8.1 + 5 \times 3.2 \times 10^{-3}$

$\boxed{V_Z = 8.116\ V}$

Para corrente em torno de $(12 - 8.2)/180 = 21\ mA$, vamos usar o seguinte modelo: $V_Z = 8.16\ V$ —— $I_Z = 10\ mA$ $\quad r_Z = \dfrac{\Delta V_Z}{\Delta I_Z} = \dfrac{0.04}{0.01} = 4\ \Omega$ //

$V_Z = 8.2\ V$ —— $I_Z = 20\ mA$

$V_{Z0} + \underbrace{4 \times 10^{-3} \times 10}_{(10\ mA)} = 8.16 \longrightarrow V_{Z0} = 8.12\ V$ //



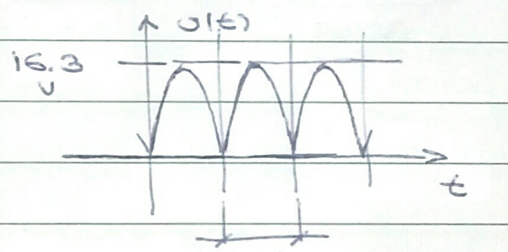
$I_Z = (12 - 8.12)/184 \longrightarrow \boxed{I_Z = 21.1\ mA}$

$V_Z = 8.12 + 4 \times 21.1 \times 10^{-3}$

$\boxed{V_Z = 8.204\ V}$

Obs.: se usássemos o modelo anterior ($V_{Z0} = 8.1\ V$ e $r_Z = 5\ \Omega$), encontraríamos $\boxed{I_Z = 21.1\ mA}$ e $\boxed{V_Z = 8.205\ V}$ (ou também — erros inferiores a 0.05% em relação ao modelo $V_{Z0} = 8.12\ V$ e $r_Z = 4\ \Omega$).

Questão 5



$T = 1/30 = 8.3\ ms$

$V_{DC} = 2 \times 16.3/\pi = 10.38\ V$

$V_{RMS} = 16.3/\sqrt{2} = 11.53\ V$

$V_{AC,RMS} = \sqrt{11.53^2 - 10.38^2} = 5.02\ V$

$r = 5.02/10.38 \longrightarrow \boxed{r = 48\%}$

$P = \dfrac{11.53^2}{120} \longrightarrow \boxed{P = 1.11\ W}$

Questão 6

Chute inicial: $r = 0.05 \longrightarrow V_{DC} = 16.3/(1 + \sqrt{3} \times 0.05) \longrightarrow V_{DC} = 15\ V$

$I_{DC} = 15/120 = 125\ mA$

Repetindo: $r = 125 \times 10^{-3}/(4 \times 1.7 \times 60 \times 0.47 \times 10^{-3} \times 16.3) = 125/3126 = 4\%$

$V_{DC} = 16.3/(1 + \sqrt{3} \times 0.04) \longrightarrow V_{DC} = 15.3\ V$

$I_{DC} = 15.3/120 = 128\ mA$

$r = 128/3126 \longrightarrow \boxed{r = 4.1\%}$

Questão 7

Chute inicial: $V_{DC} = 15\,V \longrightarrow I_{DC} = (15 - 8.2)/120 = 57\,mA$

$r = 57 \times 10^{-3} / (4 \times 1.7 \times 60 \times 0.47 \times 10^{-3} \times 16.3) = 57/3126 = 1.8\%$

Repetindo: $V_{DC} = 16.3/(1 + \sqrt{3} \times 0.018) \longrightarrow V_{DC} = 15.8\,V$

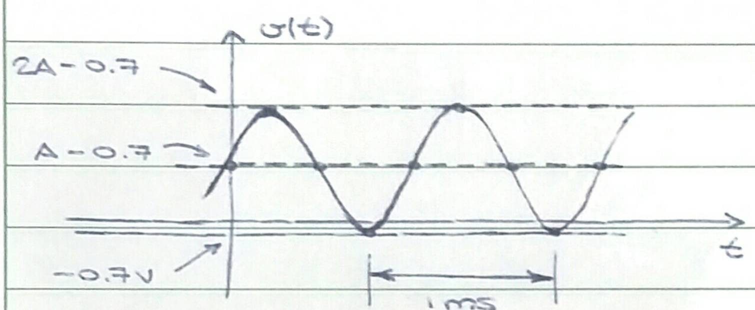
$I_{DC} = (15.8 - 8.2)/120 = 63\,mA$

$r = 63/3126 \longrightarrow \boxed{r = 2\%,\ V_{DC} = 15.8\,V}$ ⟵ Fator de ripple e voltagem DC no capacitor.

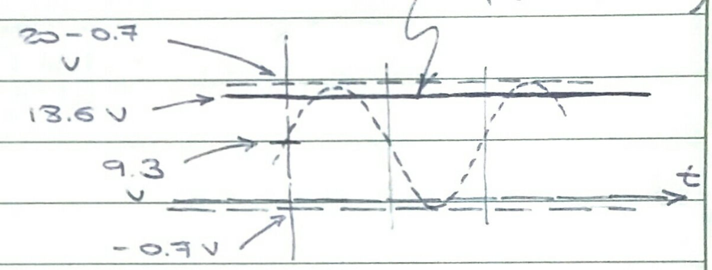
Modelo do diodo Zener: vamos assumir $V_Z \cong 8.2\,V$ (correntes em torno de 20 mA) e $r_Z \cong 5\,\Omega$ (da Questão 4).

$$r_{R_L} = 0.02 \times \frac{5}{125} \times \frac{15.8}{8.2} \longrightarrow \boxed{r_{R_L} = 0.15\%}$$

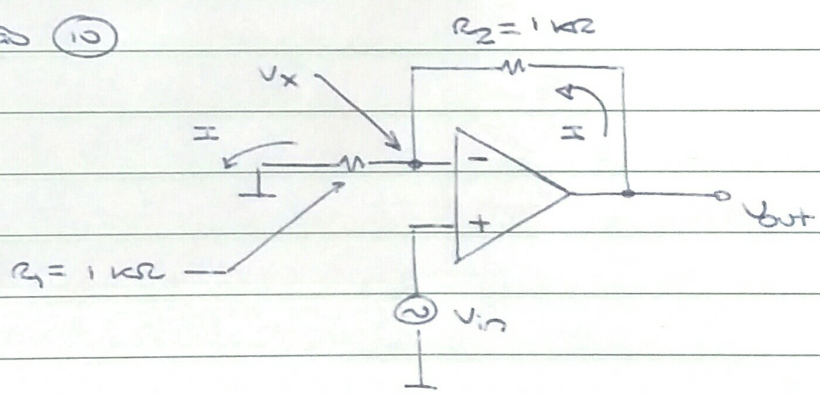
Questão 8



Questão 9



Questão 10



$1000(V_{in} - V_x) = V_{out}$

Então:

$$V_x = V_{in} - \frac{V_{out}}{1000}$$

$$I = \left(V_{in} - \frac{V_{out}}{1000}\right) / R_1$$

$$V_{out} = \left(V_{in} - \frac{V_{out}}{1000}\right) + \cancel{R_2}\left(V_{in} - \frac{V_{out}}{1000}\right) / \cancel{R_1} = 2V_{in} - \frac{2V_{out}}{1000}$$

$$V_{out}\left(1 + \frac{2}{1000}\right) = 2V_{in} \longrightarrow \frac{V_{out}}{V_{in}} = \frac{2}{1.002} \longrightarrow \boxed{\frac{V_{out}}{V_{in}} = 1.996}$$

"vírgula"