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Lista 01

2.10) $N_D = 5 \times 10^{17}\ cm^{-3}$ $\quad N_A = 4 \times 10^{16}\ cm^{-3}$

ⓐ $n_i = B . T^{3/2} . \exp(-E/2kT)$

$n_i = 5{,}2 . 10^{15}\ T^{3/2} . \exp(-1{,}792\ 10^{-19}/2 \times 1{,}38\ 10^{-23}\ 300) = 1{,}0776 . 10^{10}\ cm^{-3}$

• N

$n = N_D = 5 \times 10^{17}\ cm^{-3}$

$p = \dfrac{n_i^2}{n} = 232{,}24\ cm^{-3}$

• P

$p = N_A = 4 \times 10^{16}\ cm^{-3}$

$n = \dfrac{n_i^2}{p}$ $\quad n = 2{,}30 . 10^{9}\ cm^{-3}$

ⓑ $V_0 = ?$ $\quad T = 250K, 300K, 350K$

$T = 250K$

$n_i = 5{,}2 . 10^{15}\ (250)^{3/2} \exp(-1{,}792\ 10^{-19}/2 \times 1{,}38\ 10^{-23} . 250) = 1{,}081\ 10^{8}\ cm^{-3}$

$|V_0| = \dfrac{kT}{q} . \ln \dfrac{N_A N_D}{n_i^2} \Rightarrow V_0(250) = \dfrac{250 . 1{,}38\ 10^{-23}}{1{,}6 . 10^{-19}} \ln\left(\dfrac{5\times10^{17} \times 4\times10^{16}}{(1{,}081\ 10^{8})^2}\right) = 0{,}9053V$

$V_0(300) = 0{,}8482V$ $\quad V_0(350) = 0{,}7889V$

2.12) $N_D = 3 \times 10^{16}\ cm^{-3}$ $\quad N_A = 2 \times 10^{15}\ cm^{-3}$ $\quad V_R = 1{,}6V$

ⓐ

$n_i = 5{,}2 . 10^{15}\ 300^{3/2} . \exp(-1{,}792\ 10^{-19}/2 \times 1{,}38\ 10^{-23} . 300) = 1{,}0776\ 10^{10}\ cm^{-3}$

$V_0 = \dfrac{kT}{q} \ln \dfrac{N_A N_D}{n_i} \cong 0{,}6979V$ $\quad \varepsilon_{si} = 1{,}04 \times 10^{-12}\ F/cm$

$C_{j0} = \left(\dfrac{\varepsilon_{si} . q}{2} \dfrac{N_A N_D}{N_A + N_D} . \dfrac{1}{V_0}\right)^{1/2} = 1{,}495\ 10^{-8}\ F/cm^2$

$C_j = \dfrac{C_{j0}}{\sqrt{1 + \frac{V_R}{V_0}}} = 8{,}2395\ 10^{-9}\ F/cm^2$

ⓑ $C_j' = 2C_j = \dfrac{\sqrt{\frac{\varepsilon_{si} N_A' N_D}{2}\ \frac{1}{N_A' + N_D}\ \frac{1}{V_0}}}{(1 + V_R/V_0)} = 2C_j$? Resposta $\Rightarrow \dfrac{N_A'}{N_A} = 5{,}125$

2.14)

ⓐ $V_D = 750\,mV$ $\qquad I_D = I_S \exp\left(-\frac{V_D}{V_T}\right) = 2{,}9667 \cdot 10^{-13}\,mA$

$I_D = 1\,mA$

$V_T = 26\,mV$

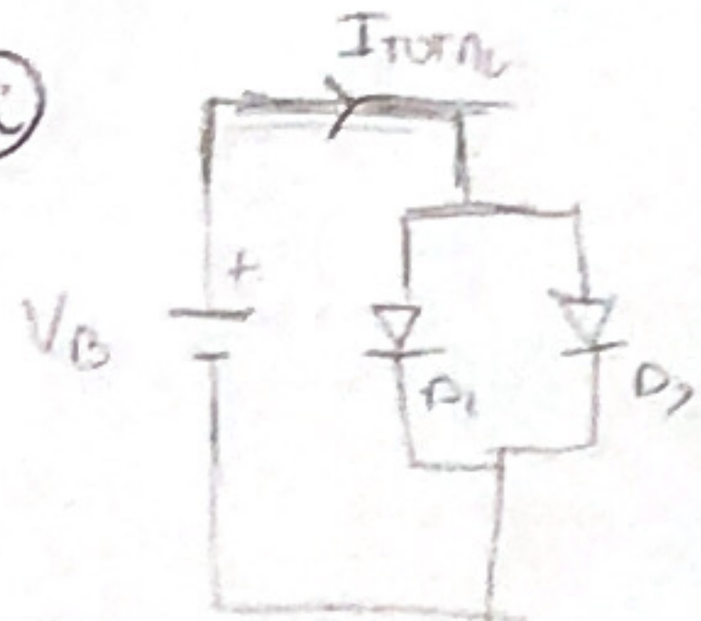
ⓑ $I_S = Aq\, n_i^2 \left(\frac{D_N}{N_A L_N} + \frac{D_P}{N_D L_P}\right)$

$I_S \propto A \Rightarrow$ dobro a área $\Rightarrow I_S' = 2I_S$

$V_d = V_T \ln \frac{I_D}{I_S'} \Rightarrow V_D = V_T \ln \frac{I_D}{2I_S} \qquad V_D = 731{,}9782\,mV$

2.15)

ⓐ



$I_{TOTAL} = I_{D1} + I_{D2} = I_{S1}\left(\exp\left(\frac{V_B}{V_T}\right) - 1\right) + I_{S2}\left(\exp\left(\frac{V_B}{V_T}\right)\right)$

$I_{TOTAL} = \underbrace{(I_{S1} + I_{S2})}_{I_R} \underbrace{\left[\exp\left(\frac{V_B}{V_T}\right) - 1\right]}$

↳ comportamento exponencial

ⓑ $V_{D1} = V_{D2} \Rightarrow$ paralelo

$\cancel{V_T} \ln \frac{I_{D1}}{I_{S1}} = \cancel{V_T} \ln \frac{I_{D2}}{I_{S2}} \Rightarrow \frac{I_{D1}}{I_{S1}} = \frac{I_{D2}}{I_{S2}}$ ①

$I_{TOTAL} = I_{D1} + I_{D2} \qquad I_{D2} = I_{TOTAL} - I_{D1}$ ②

② → ① $\quad \frac{I_{D1}}{I_{S1}} = \frac{I_{TOTAL} - I_{D1}}{I_{S2}} \Rightarrow I_{D1}\, I_{S2} = I_{S1}(I_{TOTAL} - I_{D1})$

$I_{D1} \cdot (I_{S1} + I_{S2}) = I_{S1}\, I_{TOTAL}$

$I_{D1} = \frac{I_{S1}\, I_{TOTAL}}{I_{S1} + I_{S2}}$

$\Rightarrow$ Equivalente $V_{D2} \Rightarrow I_{D2} = \frac{I_{S2}\, I_{TOTAL}}{I_{S1} + I_{S2}}$

2.17) $V_B = V_{D1} + V_{D2} \qquad V_B = V_T \ln \frac{I_B}{I_{S1}} + V_T \ln \frac{I_B}{I_{S2}}$

$\boxed{V_B = V_T \ln \frac{I_B^2}{I_{S1} I_{S2}}}$

$\frac{V_B}{V_T} = \ln \frac{I_B^2}{I_{S1} I_{S2}} \qquad \exp\left(\frac{V_B}{V_T}\right) = \frac{I_B^2}{I_{S1} I_{S2}} \qquad \boxed{I_B = (I_{S1} I_{S2} \exp(V_B/V_T))^{1/2}}$

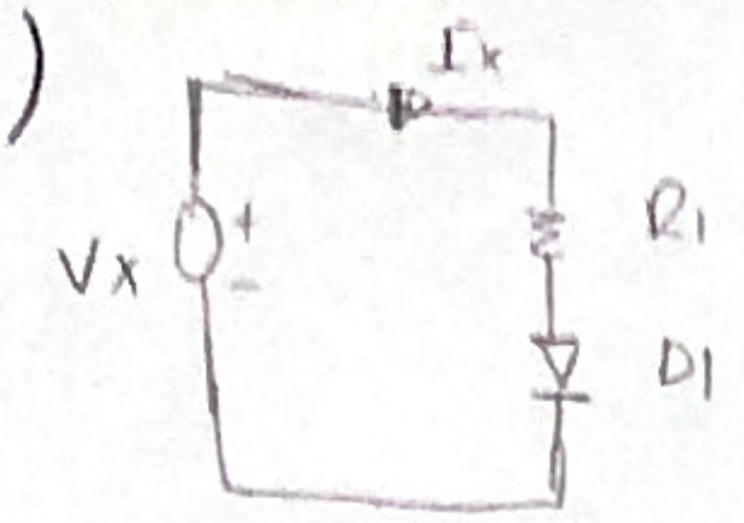
$V_{D1} = V_T \ln I_B / I_{S1} = V_T \ln \frac{(I_{S1} I_{S2} \exp(V_B/V_T))^{1/2}}{I_{S1}}$

$V_{D1} = V_T \cdot \ln \left(\frac{I_{S1}}{I_{S2}}\right)^{1/2} + V_B/2$ //

Equivalente:

$V_{D2} = V_T \ln \left(\frac{I_{S2}}{I_{S1}}\right)^{1/2} + V_B/2$ //

2.23)



Vx	Ix
1V	0.2mA
2V	0.5mA

$V_{D1} = V_T \ln \frac{I_x}{I_S}$ $\quad V_T = 26mA$

$V_{D1} = V_x - R_1 . I_x$

$$V_x - R_1 I_x = V_T \ln \frac{I_x}{I_S}$$

① $1 - R_1 . 0{,}2 = 26.10^{-3} \ln \frac{0.2\ 10^{-3}}{I_S}$

② $2 - R_1 . 0{,}5 = 26.10^{-3} \ln \frac{0.5.10^{-3}}{I_S}$

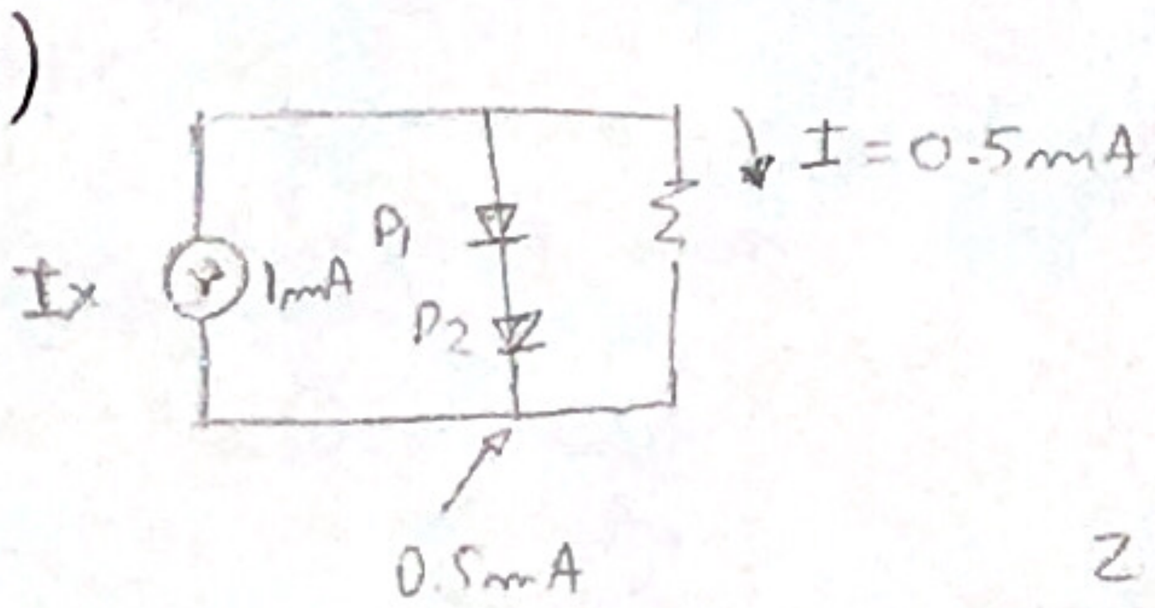
②-① $\Rightarrow$ $1 - R_1 (0{,}5 - 0{,}2)\ 10^{-3} = 26\ 10^{-3} \ln \frac{0{,}5.\cancel{10^{-3}}}{\cancel{I_S}} . \frac{\cancel{I_S}}{0{,}2.\cancel{10^{-3}}}$

$1 - R_1 (0{,}3\ 10^{-3}) = 26.10^{-3} \ln \frac{0{,}5}{0{,}2}$ $\Rightarrow$ $R_1 = 3{,}2539\ K\Omega$

$I_S = I_D \exp(-V_D/V_T) = I_D \exp\left(-\frac{(V_x - R_1 I_x)}{26.10^{-3}}\right)$

$= 0{,}5 \exp\left(\frac{-(2 - 3{,}2539.\cancel{10^{3}} . 0{,}5.\cancel{10^{-3}})}{26\ 10^{-3}}\right)$ $\quad I_S = 2{,}9362\ 10^{-10} A$

2.29)



$I_S = 5.10^{-16} A$ $\quad R_1 = ?$

$V_D = V_T \ln \frac{I_D}{I_S}$ $\rightarrow$ 0.5 mA

$2 V_D = R_1\ 0{,}5.10^{-3}$

$0{,}25.10^{-3} R_1 = 26.10^{-3} \ln \frac{0{,}5.10^{-3}}{5.10^{-16}}$ $\Rightarrow$ $R_1 = \frac{26.10^{-3}}{0{,}25\ 10^{-3}} \ln \frac{0{,}5.10^{-3}}{5.10^{-16}}$

$R_1 = 2{,}87\ K\Omega$