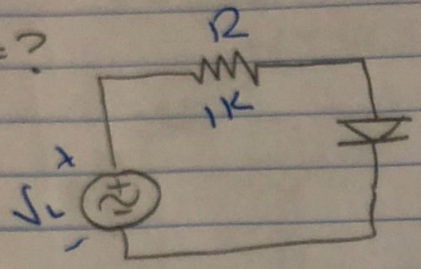
Keeyan Haghshenas
RUID: 171000841
02/08/2019
DE HW

DE Homework #1:

1) $T_s = ?$



$$I_S = \frac{V_S - V_J}{R}$$

$$I_S = \frac{2 - 0.65}{1K} = 1.35mA$$

$$I_B = \frac{V_J - V_C}{B} = \frac{.65 + 20}{1000} = 20.65mA$$

$$T_S = T_P \ln\left[1 + I_S / I_B\right] = 1ns \ln\left[1 + 1.35 / 20.65\right]$$

$$\boxed{T_S = 63.33ns}$$

2) $T_S = ?$
$t_f = ?$

$$T_S = T_F \ln\left[1 + I_S / I_R\right] = 167ns \cdot \ln\left[1 + \frac{10mA}{20mA}\right] = \boxed{67.7ns}$$

Discharging:

$$T = RC = 500(5pF) = 2.5ns$$

$$t = -T \ln(.1) = \boxed{5.76ns}$$

3) $I_{S1} = 10^{-14}\,A$

$I_{S2} = 100 I_{S1}$

Find I, V

$$I_{S1} e^{V_1/V_T} = I_{S2} e^{V_2/V_T}$$

$$I_{S1} e^{V_1/V_T} = 100 I_{S1} e^{V_2/V_T}$$

$$e^{\frac{V_1 - V_2}{V_T}} = 100$$

$$V_1 - V_2 = V_T \ln(100)$$

$V_T = 26mV$

$V_1 - V_2 = 0.115V$

$V_1 + V_2 = 1V$

$$2V_1 = 1.115V$$

$$V_1 = 0.558V$$

$$V_2 = 0.443V$$

$$I = 10^{-14} e^{\frac{.558}{25mV}} = 4.95 \times 10^{-5} A = \boxed{49.4\,\mu A}$$

4)

a) $V_0 = V_T \ln(N_A N_D / n_i^2)$

$$V_0 = 25mV \cdot \frac{\ln(10^{15} 10^{17})}{(1.5 \cdot 10^{10})^2} = \boxed{0.697V}$$

$C_{j0} = \varepsilon_s A / W_d$, $W_d = \left[(2\varepsilon/q) \left[\frac{N_A + N_D}{N_A N_D} \right] (V_0 - V_D) \right]^{1/2}$

$$C_{j0} = \frac{(11.8 \cdot 8.854 \times 10^{-14} / 1.6 \times 10^{-16})}{96 \times 10^{-6}} = \frac{((2 \cdot 1.8) \cdot 8.854 \cdot 10^{-14}) / 1.6 \times 10^{-19}}{\cdot \left[\frac{10^5 \cdot 10^{17}}{10^{15} 10^{17}} \right] \cdot (.697) \Big]^{1/2}}$$

$= 96 \times 10^{-6}\,cm$, $A = 46 \times 40 um^2$

$= \boxed{1745F = C_{j0}}$

$$C_j(av) = \frac{2 \cdot C_{j0}}{(1+K)^{1/2}} = \frac{2 \cdot 174}{(1+14.3)^{1/2}} = 88.85F$$

$$\boxed{C_j(av) = 88.85F}$$

$$K = \frac{1.0}{0.07} = 14.3$$

B) ② $V_D = 1.0$

$$W_D = ((2\,(11.8)\,(8.854\times10^{-14}))/1.6\times10^{-19} \cdot \left(\frac{10^{15}+10^{17}}{10^{17}\cdot 10^{17}}\right) \cdot 0.697+1.0)^{1/2} = 376.5\times10^{-6}\,cm$$

$$C_j = \frac{(11.8 \cdot 8.854\times10^{-14} \cdot 1.6\times10^{-6})}{375.5\times10^{-6}\,cm} = \boxed{44.6\times10^{-15} = C_j}$$

② $V_D = 0.5$

$$W_D = ((2\varepsilon/q)\left[\frac{N_A+N_D}{N_A N_D}\right](0.697-0.5))^{1/2}$$

$$W_D = 51\times10^{-6}\,cm$$

$$C_j = \frac{(11.8 \cdot 8.854\times10^{-14} \cdot 1.6\cdot10^{-6})}{51\cdot10^{-16}} = \boxed{327.9\times10^{-15} = C_j}$$

5)

a) I_D @ $t < t_1$

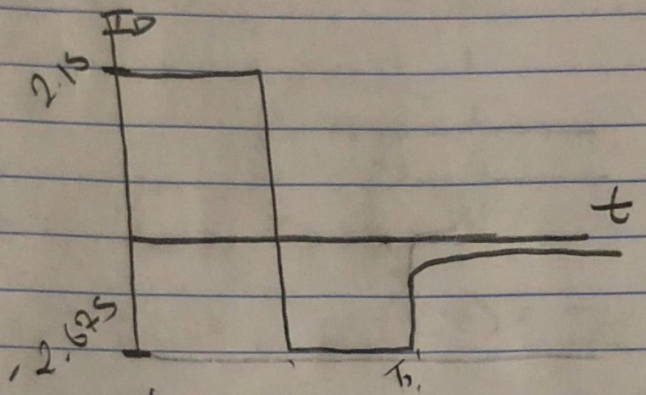
closed switch

$I_D = \frac{5 - 0.7}{2000} = \boxed{2.15\,mA}$

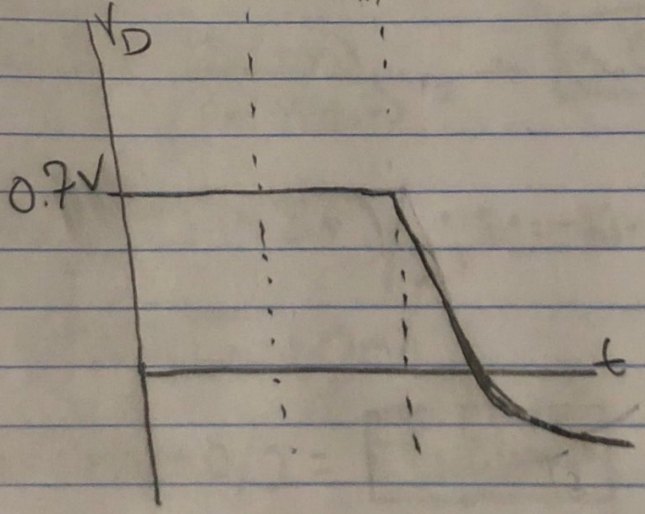
b) I_D @ $t = t_1$

$I_D = \frac{-10 - 0.7}{4000} = \boxed{-2.675\,mA}$

c)



d)



e) $T_S = J_T \ln\left(\frac{I_{D1} - I_{2D}}{-I_{D2}}\right) = (10n) \ln\left(\frac{2.15 + 2.625}{2.675}\right)$

$= \boxed{5.9nS}$

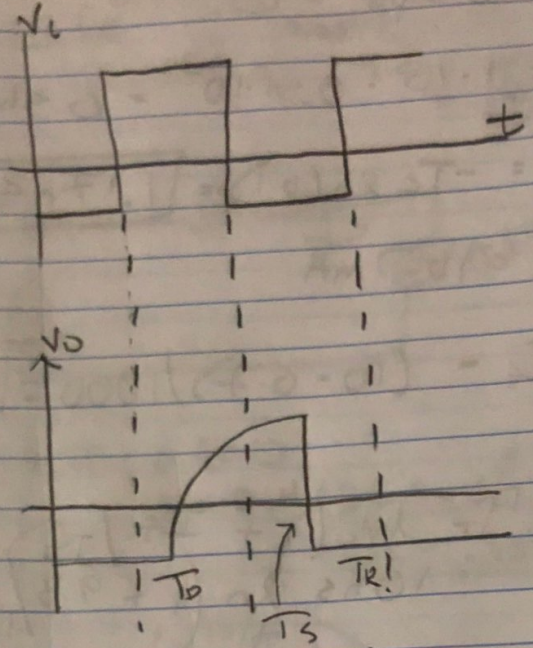
5)

$t_2 - t_1 = T_{12} = 2.2 R_S C_j = 2.2 \cdot 2k \cdot 2p$

$= \boxed{8.8nS}$

g) $Q = CV$ $C = 5pF$ $\boxed{Q = -5pC}$

a)



b) $C_j(0V) = 2pf$, $C_j(0.7) = 2C(0V) = 4pf$

$$C_j(-10V) = \frac{C_j(0V)}{(1+10/0.7)^{1/2}} \rightarrow \boxed{0.51pF}$$

c) $I_{av(R)} = (I_i + I_f)/2$; $I_i = -10 - 0.7/1k\Omega = 10.7mA = I_i$

$I_f = -10 + 10/1k\Omega = 0mA$

$I_{av(D)} = -10.7mA + 0/2 = \boxed{-5.35mA}$

D) $Q_1 = 4pf \cdot 0.7V = 2.8pC$

$Q_2 = .51pf \cdot -10V = -5.1pC$

$\Delta Q = -5.1pC - 2.8pC = \boxed{-7.9pC}$

E) $T_R = \Delta t = \frac{\Delta Q}{I_{AV(D)}} = -7.9pC / -5.35mA = \boxed{1.48ns}$

f) $C_{jav} = 0.51pf = C$

$RC = 1 \cdot 10^3 \cdot 0.51 \cdot 10^{-12} = 0.51ns$

$T_R = -T_c \ln(0.1) = \boxed{1.17ns}$

g) $I_{ri} = 10.7mA$

$I_f = (10 - 0.7)/1000 = \boxed{9.3mA}$

h)

$T_s = T_T \ln(1 + I_f/I_R)$

$10ns \ln\left(1 + 9.3/10.7\right) = \boxed{T_s = 6.25ns}$

i)

a) $I_f = \frac{5 - V_D}{1K} = \frac{4.3}{1K} = \boxed{4.3mA}$

$I_R = \frac{-5 - V_D}{1K} = \frac{-5.7}{1K} = \boxed{-5.7mA}$

b)

$C_0 = 2C_j(0)$

$2(1pF)$

$= \boxed{2pF}$

c) $T_s = T_T \ln(1 + I_f/I_R)$

$= 10 \cdot 10^{-9} \ln(1 + (4.3/5.7))$

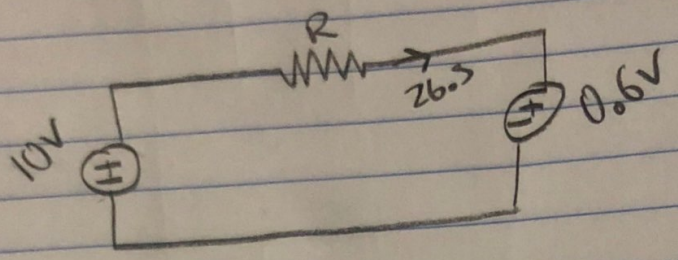
$= \boxed{5.64ns}$

d) $\frac{C_j(0)}{(1 + V_R/V_{bi})^{1/2}} = 1pF/\sqrt{8.143} = \boxed{.35pF}$

a) $I_D = I_S(e^{V_D/V_T} - 1)$

$1\times10^{-12}(e^{0.6/0.025} - 1) = \boxed{26.5\text{mA}}$

b)



$-10V + 26.5R + 0.6 = 0$

$R = 9.4/26.5\times10^{-3}$

$\boxed{R = .355\text{k}\Omega}$

c) $I_D = I_D + e(e^{V_D/V_T} - 1)$

$I_D = I_D / e^{V_D/V_T} - 1 = 26.5\text{mA} / e^{0.6/25\times10^{-3}} - 1 = \boxed{1\times10^{-12} = I_D}$ Reverse

d) $T_S = \tau_T \ln[1 + I_D/I_D]$

$(.01\,\mu s)[\ln[1 + 26.5\text{mA}/1\times10^{-12}]]$

$\boxed{T_S = 2.4\times10^{-7}\,s}$

e)

$C_D = \tau_T \frac{I_D}{nV_T} \rightarrow [26.5\text{mA}/1\,V_T](0.01\,\mu s)$

$= \boxed{1.06\times10^{-8}\,F}$