11.2) Occupancy of a state at conduction band edge

For: Ge, Si, e diamond @ 300k

11.35: $f(E) \approx e^{-(E-E_F)/kT}$

(fermi-dirac dist.)

where:

$T = 300k$

k = boltzman constant

1.38e-23

For given semiconductors $E_F = \frac{1}{2} E_{gap}$

For Ge - $E_g = 0.67$ eV

$f(E) = 2.54e-6$

Si - $E_g = 1.11$ eV

$f(E) = 5.38e-10$

Diamond - $E_g = 5$ eV

$f(E = 1.74e-42$

also given that $kT = 0.026$ @ room temp.

Pg. 155

1.1.3) a) Si doped with 10^{17} As atoms/cm^3

equilibrium hole concentration @ 300K

Law of mass action equations

$$n_0 \cdot p_0 = n_i^2$$

- intrinsic carrier concentration

electron equilibrium $= 10^{17}$

hole equilibrium carrier concentration

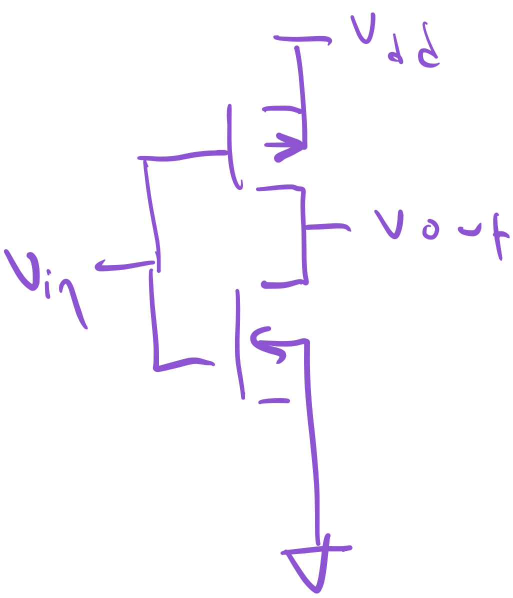
<u>solve</u>

$$p_0 = \frac{n_i^2}{n_0} = \frac{(10^{10})^2}{10^{17}} = 10^3 \ cm^3$$

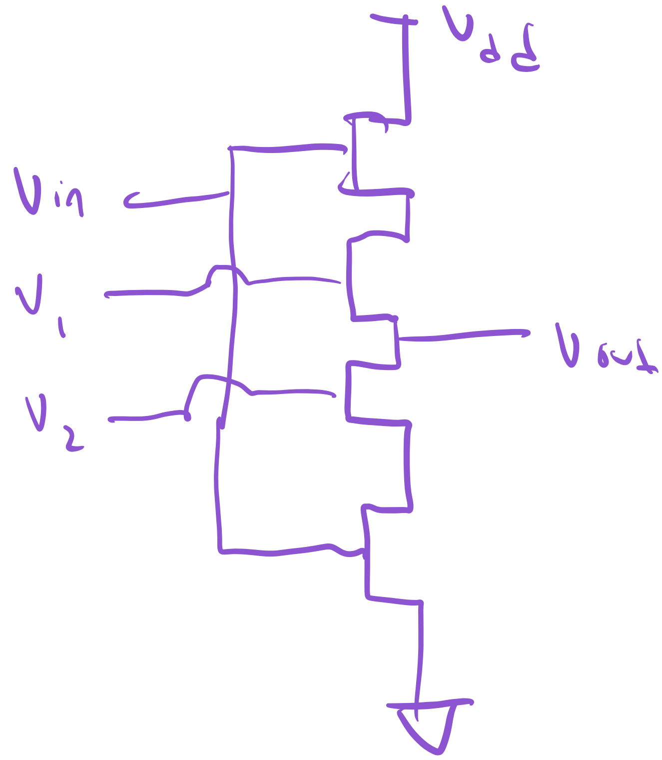
11.4) Design a tristate CMOS inverter

from google:

CMOS INVERTER

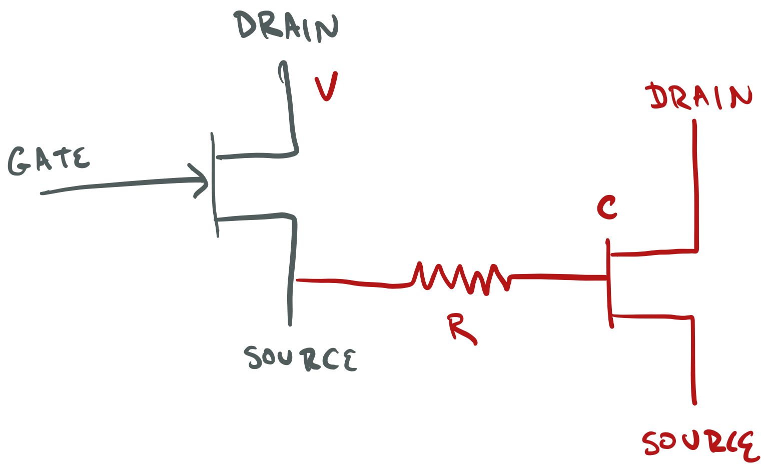


TRISTATE



we can now float V_{out} by opening transistors driven by V_1 + V_2 + still ground it or drive it to V_{dd}

11.5)



$V = 1.8\,V$

$C = 1\,fF$

$= 1e{-15}\,F$

a) $U_c = \frac{1}{2} V^2 C = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2} q V$

$= \frac{1}{2}(1.8)^2 (1e^{-15}) = 1.62e{-15}\ J$

b) Let's start by getting total charge moved

$U = 1.62e{-15} = \frac{1}{2} q V \xRightarrow[\text{solve for } q]{} 1.8e{-15}\ C$

Then we know:

$P = IV = \frac{\Delta q \cdot V}{\Delta t}$ multiply by Δt to get rid of time dependence

$U = \Delta q V = 1.8e^{-15}(1.8) = 3.24e{-15}\ J$

I believe we've added back in our 1/2 energy so this should make sense as total energy that's travelled along the wire

$\therefore\ U_{\text{dissapated}} = 1.62e{-15}\ J$

c) as time τ approaches ∞ we should dissipate 0 energy

same way $P = T \cdot rpm$ when $rpm = 0$

average current $I = q/\tau = \frac{CV}{\tau}$

$V = IR = \frac{CVR}{\tau}$

now for average power $P = VI$

$P = \frac{CVR}{\tau}\left(\frac{CV}{\tau}\right) = \frac{C^2V^2R}{\tau^2}$

integrate over time for energy

$U = \frac{C^2V^2R}{\tau}$

d) If one cycle costs $2(1.62e^{-15})$ J,

$P = U/s$ so in for 1 w we want:

$1 = 2(1.62e^{-15}) \cdot n$ $\quad n = 3.08e14$ cycles

e) $10^9 \cdot (\; 3.24e{-15})) \cdot 10^9 \frac{\text{cycles}}{s}$

total transistors

energy to cycle

cycles/s

3240 w or 3.24 kw (seems way too high

f) we established $q = 0.9e^{-15}$ where $1C = 6.24e^{18}$

so 5616 electrons