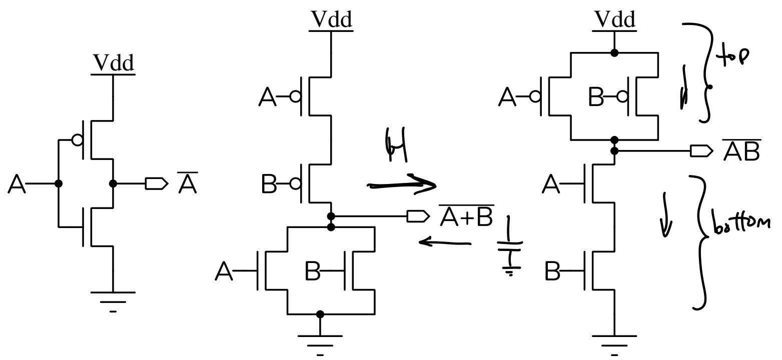
Implementation of Digital Logic Circuits

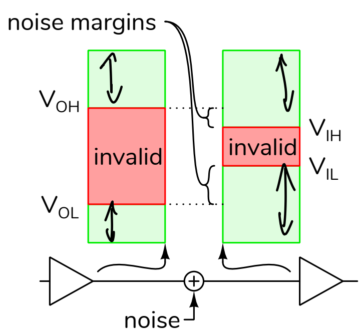
Exercise 1:



A	B	top	bottom
0	0	ON	OFF
0	1	ON	OFF
1	0	ON	OFF
1	1	OFF	ON

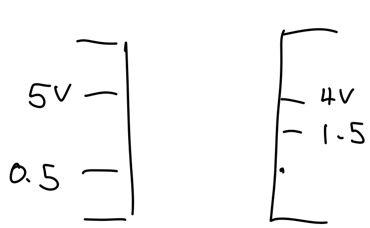
In which direction does the output current flow when the output is high? When it is low? Which transistors in the NAND circuit are on (conducting) in each case?

Exercise 2:



Which of these specifications does the manufacturer guarantee? all
Which are requirements? → none

Exercise 3: A logic family has V_{OH}(min) = 5 V, V_{OL}(max) = 0.5 V, V_{IH}(min) = 4 V and V_{IL}(max) = 1.5 V. What are the noise margins?



noise margin (high) = 5 - 4 = 1

" " (low) = 1.5 - 0.5 = 1

Exercise 4: All else being equal, by how much would we expect to decrease power consumption when reducing logic levels from 5 V to 3.3 V? What would be the effect on power consumption in reducing the clock frequency from 50 MHz to 1 MHz?

$$\frac{P_2}{P_1} = \frac{f_2}{f_1}\left(\frac{V_2}{V_1}\right)^2 \qquad f_2 = f_1,\ V_2 = 3.3,\ V_1 = 5$$

$$\frac{P_2}{P_1} = \left(\frac{3.3}{5}\right)^2 = 0.44 \qquad P_2 = 0.44 P_1$$

power reduced by 56%

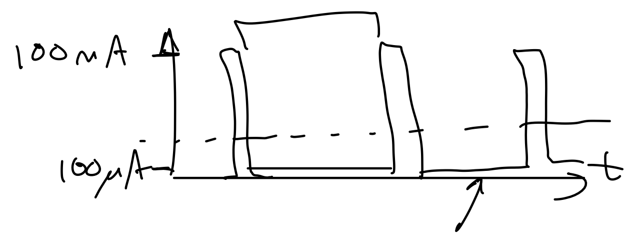
$$\frac{P_2}{P_1} = \frac{f_2}{f_1}\left(\frac{V_2}{V_1}\right)^2 \qquad V_2 = V_1,\ f_2 = 1,\ f_1 = 50$$

$$P_2 = P_1\left(\frac{1}{50}\right) = 0.02 P_1$$

new power is 2% of original

Exercise 5: The energy stored in a battery (its "capacity") is measured in Amp-hours. If a circuit draws 100 mA for 100 μs per second and draws 100 μA the rest of the time, how long will a 1000 mAh battery last?

capacity = I · T (I: mA / A; T: s / hours)

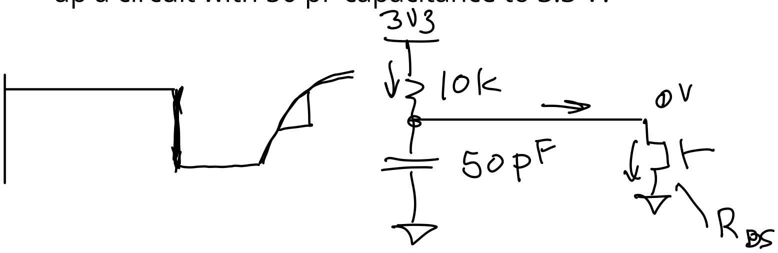


$$I_{average} = \frac{\overbrace{100\times10^{-6}}^{100\mu s}\cdot\overbrace{100\times10^{-3}}^{100mA} + (1-100\times10^{-6})\times\overbrace{100\times10^{-6}}^{100\mu A}}{1s}\ A$$

$$= \frac{10^{-5} + 10^{-4} - 10^{-10}}{1} \approx 1.1\times10^{-4}\ A$$

$$T = \frac{\text{capacity}}{I} = \frac{100\times10^{-3}\ A\cdot h}{1.1\times10^{-4}\ A} \approx 900 \text{ hours}$$

Exercise 6: What are the active-state current and the RC time constant for a wired-or interrupt-request line using a 10kΩ resistor pulling up a circuit with 50 pF capacitance to 3.3 V?



$$I = \frac{V}{R} = \frac{3.3}{10k} = 0.33\,mA$$

$$P = \frac{V^2}{R} = \frac{(3.3)^2}{10K} = 1\,mW$$

$$RC = 10 \times 10^{3} \times 50 \times 10^{-12}$$

$$= 500 \times 10^{-9} = 0.5\,\mu s$$

Exercise 7: How many square mm of PCB area does each package require? Which packages have their pins accessible when the package is placed on the PCB?

$$22 \times 22\ mm = 484\ mm^2$$

$$3.5 \times 3.5\ mm = \sim 12\ mm^2$$

DIP & TQFP = accessible pins.