EECS 16B Designing Information Devices and Systems II
Fall 2021 Discussion Worksheet

Discussion 1A

For this discussion, Note 1 is helpful for background in transistors and RC circuits.

1. NAND Circuit

Let us consider a NAND logic gate. This circuit implements the boolean function $\overline{(A \cdot B)}$. The $\cdot$ stands for the AND operation, and the $\overline{\quad}$ stands for NOT; combining them, we get NAND!

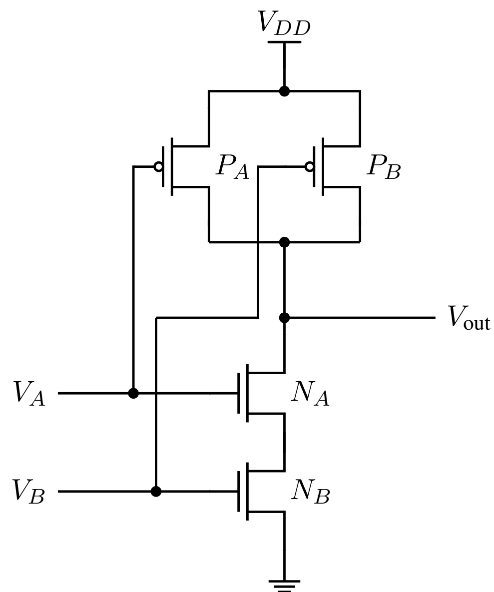

Figure 1: NAND gate transistor-level implementation.

V_{tn} and V_{tp} are the threshold voltages for the NMOS and PMOS transistors, respectively. Assume that $V_{DD} > V_{tn}$ and $|V_{tp}| > 0$.

(a) Label the gate, source, and drain nodes for the NMOS and PMOS transistors above.

(b) If $V_A = V_{DD}$ and $V_B = V_{DD}$, which transistors act like open switches? Which transistors act like closed switches? What is V_{out}?

(c) If $V_A = 0V$ and $V_B = V_{DD}$, what is V_{out}?

(d) If $V_A = V_{DD}$ and $V_B = 0V$, what is V_{out}?

(e) If $V_A = 0V$ and $V_B = 0V$, what is V_{out}?

(f) Write out the truth table for this circuit.

V_A	V_B	V_{out}
0	0	
0	V_{DD}	
V_{DD}	0	
V_{DD}	V_{DD}	

2. RC Circuits - Part I

In this problem, we will find the voltage across a capacitor over time in an RC circuit. In this part, we set up our problem by first defining four functions over time: $I(t)$ is the current at time t, $V(t)$ is the voltage across the circuit at time t, $V_R(t)$ is the voltage across the resistor at time t, and $V_C(t)$ is the voltage across the capacitor at time t.

Recall from 16A that the voltage across a resistor is defined as $V_R = RI_R$ where I_R is the current across the resistor. Also, recall that the voltage across a capacitor is defined as $V_C = \frac{Q}{C}$ where Q is the charge across the capacitor.

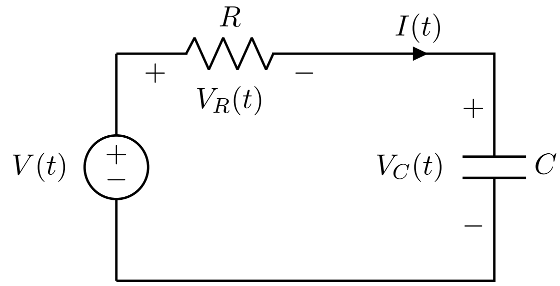

Figure 2: Example Circuit

(a) First, find an equation that relates the current across the capacitor $I(t)$ with the voltage across the capacitor $V_C(t)$.

(b) Write a system of equations that relates the functions $I(t)$, $V_C(t)$, and $V(t)$.

(c) So far, we have two relations between I(t) and $V_C(t)$. To solve this system of equations, we can remove

$I(t)$ from the equation using what we found in part (a). Rewrite the previous equation in part (b) in the form of a differential equation.

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