Hardware - Tutorial 3
Sequencial Logic

Exercice 1: Adding numbers

Adding numbers in binary is quite similar to adding numbers in decimal. We add digits of the same column and a possible carry from the previous column. We obtain a result and a possible carry for the next column.

We want to design a circuit that is able to add 4 bits binary numbers together. Let us first design a circuit called a "Full adder" that adds 2 bits and a possible carry.

The circuit will have:

- 3 inputs (A, B and Ri) that respectively represents the 2 input bits and the input carry
- 2 outputs (S and R) that respectively represents the result and the output carry.

1) Write down the thruth table of S and R.

2) Fill up two Karnaugh map with theses truth tables and extract the most simplified expression of S and R.

3) Draw the circuit diagram of the full adder.

Using 4 full adders, we want to design a 4-bits adder.

4) Draw the circuit diagram of the 4-bits adder. It must have a 1 bit input carry and a 1 bit output carry.

Exercice 2: Subtracting numbers

The same way a full adder adds bits, a full subtractor is a circuit that subtracts two bits (A and B) and a possible borrow (Ri). It generates the difference D and a possible output borrow R.

We want to design a full subtractor.

1) Write down the truth tables of D and R.

2) Fill up Karnaugh maps to find the most simplified expressions of these outputs.

3) Draw the circuit diagram of the full subtractor.

Using 4 full subtractors, we want to design a 4-bits subtractor.
4) Draw the circuit diagram of the 4-bits subtractor.

Exercice 3: Adder-Subtractor

1) Design a circuit with one output (S) and two inputs (E and C).

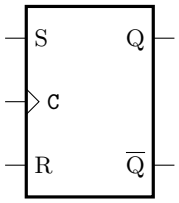
- If $C = 0$ then $S = E$
- If $C = 1$ then $S = \bar{E}$

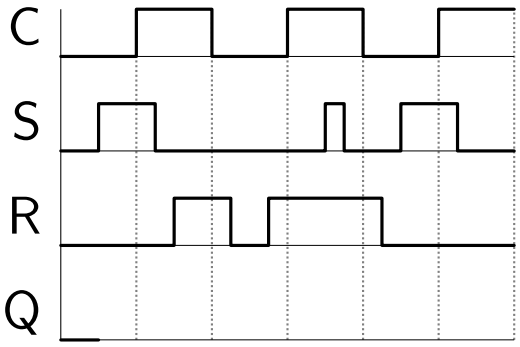
2) Using the circuit from the previous question and a 4-bits adder, design a 4-bits adder-subtractor that can either add two 4-bits numbers or subtracts them depending on a C input.

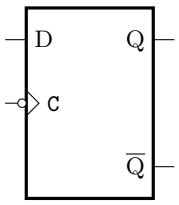
- If $C = 0$ then $S = A + B$
- If $C = 1$ then $S = A - B$

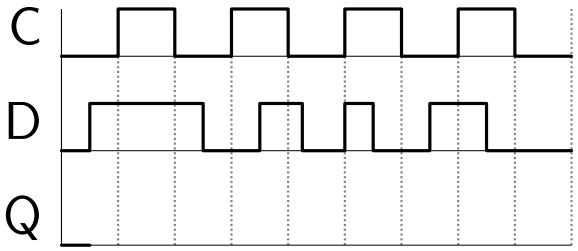
Exercice 4: Flip Flops

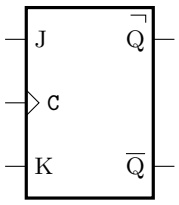
Complete the following timing diagrams for each flip flop. Beware of the synchronisation mode of each flipflop.

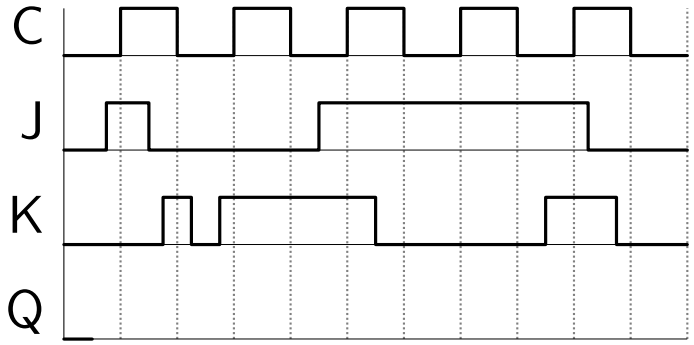


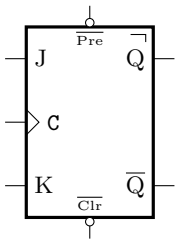


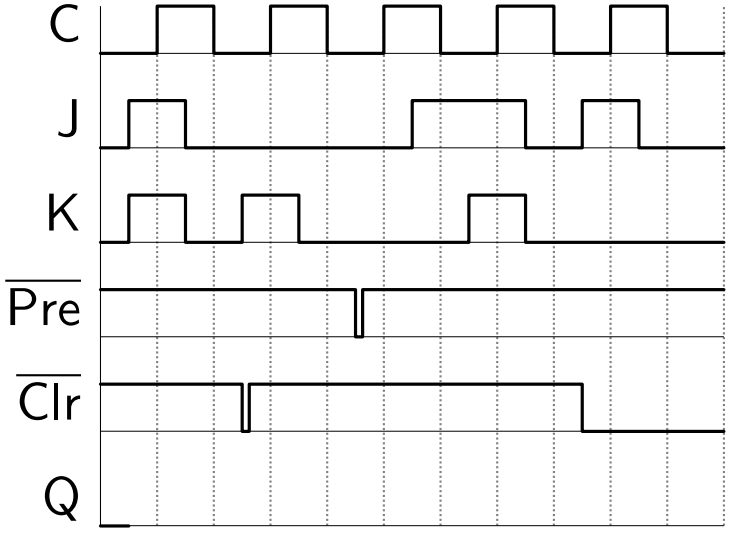





J
Q
C
K
$\overline{Q}$


C
J
K
Q


$\overline{Pre}$
J
Q
C
K
$\overline{Q}$
$\overline{Clr}$


C
J
K
$\overline{Pre}$
$\overline{Clr}$
Q

Exercice 5: Circuit Analysis

Given the following sequencial circuit:

- Fill the related timing table
- Find the purpose of such a circuit