# Task 1

In this section, a state machine will be developed for controlling the switching on and off of two pumps, to fill a tank. The are controlled by two sensors from the upper part of the tank (S) and the lower part of the tank (I). The actions to take are as follows:

- Tank full: S = I = 1 - Pumps OFF
- Tank empty: S = I = 0 - Pumps ON
- Half full tank: S = 0 & I = 1 - Pumps alternate

With this in mind, a Moore machine is developed as follows.

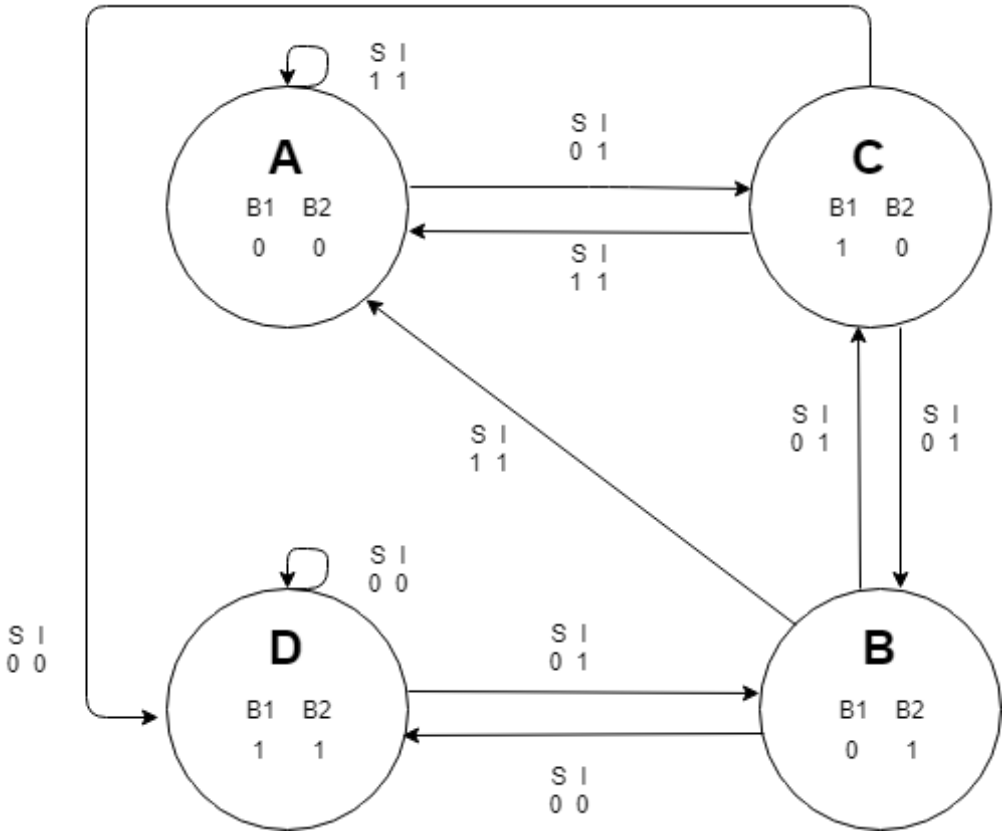


Figure 1: Moore state machine diagram

Using two bits to asign the states, a table of transitions is made, as shown below.

| Estado Actual | | Estado Siguiente | | | | Salidas | |
|---|---|---|---|---|---|---|---|
| | y2 - y1 | S - I | | | | B1 | B2 |
| | | 00 | 01 | 10 | 11 | | |
| A | 00 | X | C | X | A | 0 | 0 |
| B | 01 | D | C | X | A | 0 | 1 |
| C | 10 | D | B | X | A | 1 | 0 |
| D | 11 | D | B | X | X | 1 | 1 |

Figure 2: Moore state machine - Transitions

From the table, using Karnaugh's maps (see resolution in *Annex*) the functions for the state variables and the two pumps outputs result as:

$$Y_2 = \overline{I} + \overline{S} \cdot \overline{y_2}$$

$$Y_1 = \overline{I} + \overline{S} \cdot y_2$$

And for the outputs: $B_1 = y_2$ and $B_2 = y_1$. Finally, the state machine is implemented using D Flip Flops:

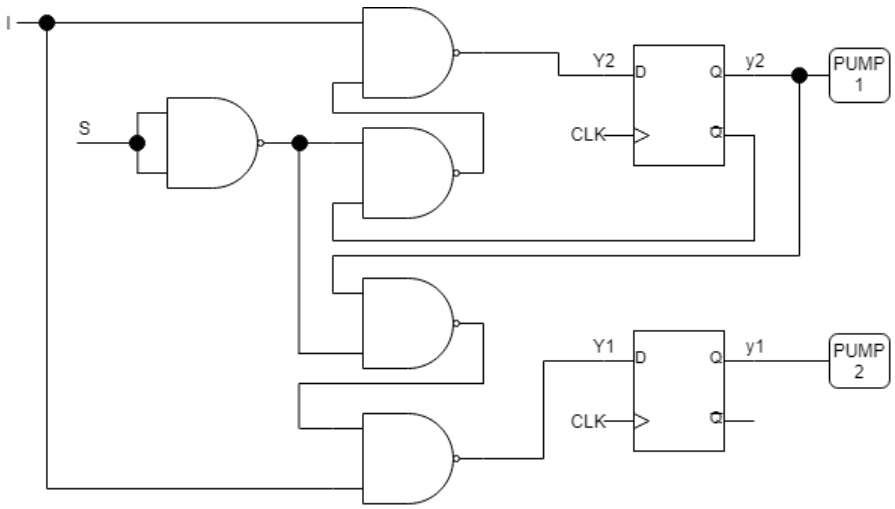


Figure 3: Moore state machine - Circuit implementation

On the other side, the same system is implemented now using a Mealy state machine, as shown below.

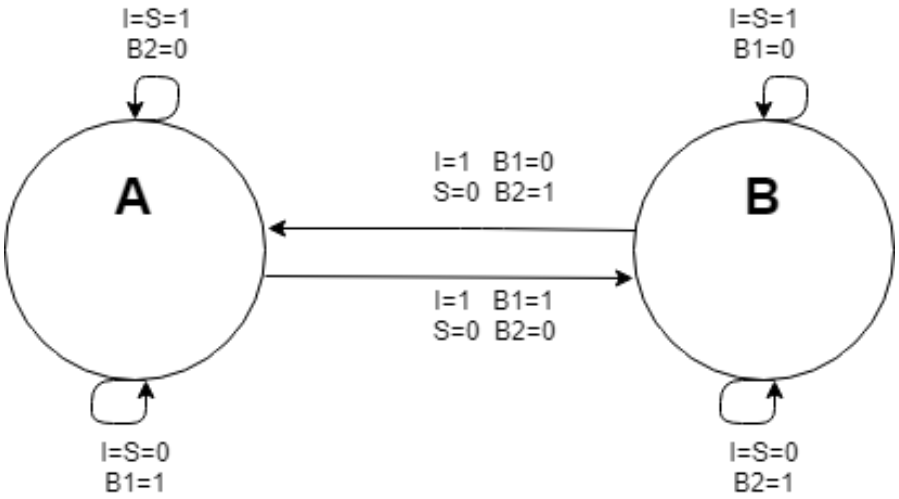


Figure 4: Mealy state machine diagram

Notice that the direct connection between the input and the pumps outputs reduces the number of states from four to two, in comparison with the Moore machine. Using one bit for the states, a table of transitions is made as follows.

| Estado Actual | | Estado Siguiente | | | | Salidas | | | |
|---|---|---|---|---|---|---|---|---|---|
| | y | S - I | | | | S - I | | | |
| | | 00 | 01 | 10 | 11 | 00 | 01 | 10 | 11 |
| | | y | | | | B1 - B2 | B1 - B2 | B1 - B2 | B1 - B2 |
| A | 0 | A | B | A | X | 11 | 10 | XX | 00 |
| B | 1 | B | A | B | X | 11 | 01 | XX | 00 |

Figure 5: Mealy state machine - Transitions

Using again Karnaugh's maps (see resolution in *Annex*), the functions for the state variable and the two pumps outputs are:

$$Y = \overline{y} \cdot \overline{S} \cdot I + y \cdot \overline{I} + y \cdot S$$

For the outputs: $B_1 = \overline{y} \cdot \overline{S} + \overline{S} \cdot \overline{I}$ and $B_2 = \overline{S} \cdot \overline{I} + y \cdot \overline{S}$. Finally, the state machine is implemented using one D Flip Flop.

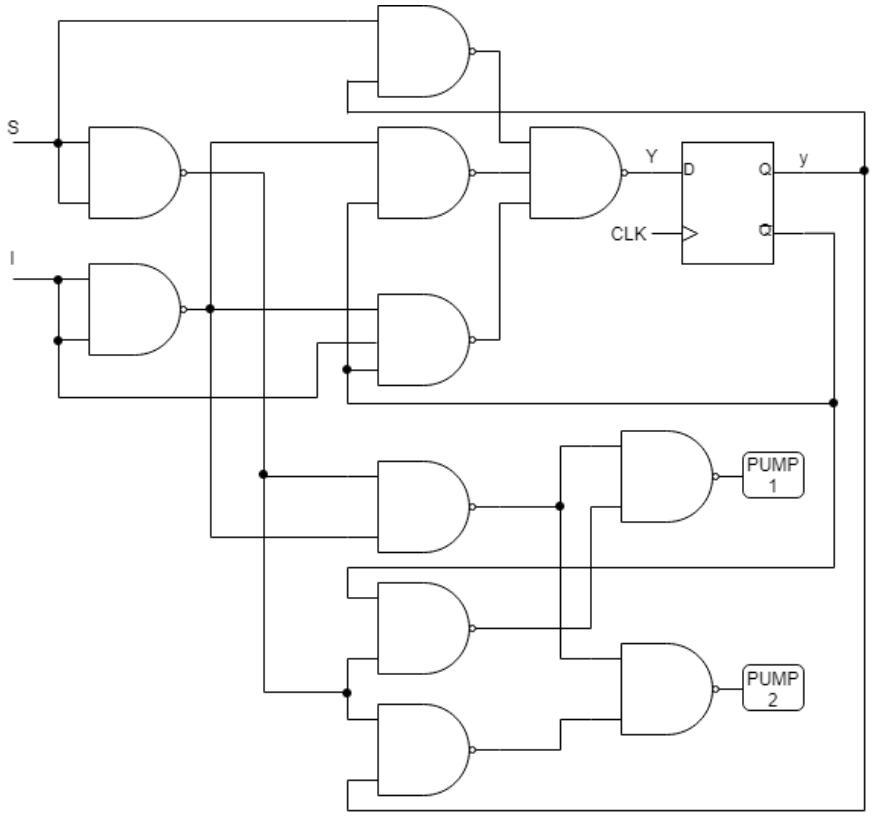


Figure 6: Mealy state machine - Circuit implementation