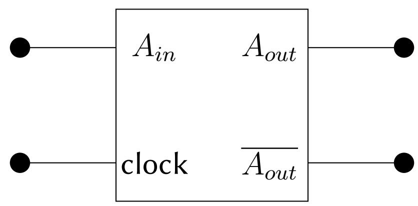
Math-42 Sections 01, 02, 05

Homework #2 Solutions

Problem

A flip-flop or latch is a device the locks the binary value on its input to its output upon a clock pulse (a transition from 0 to 1):

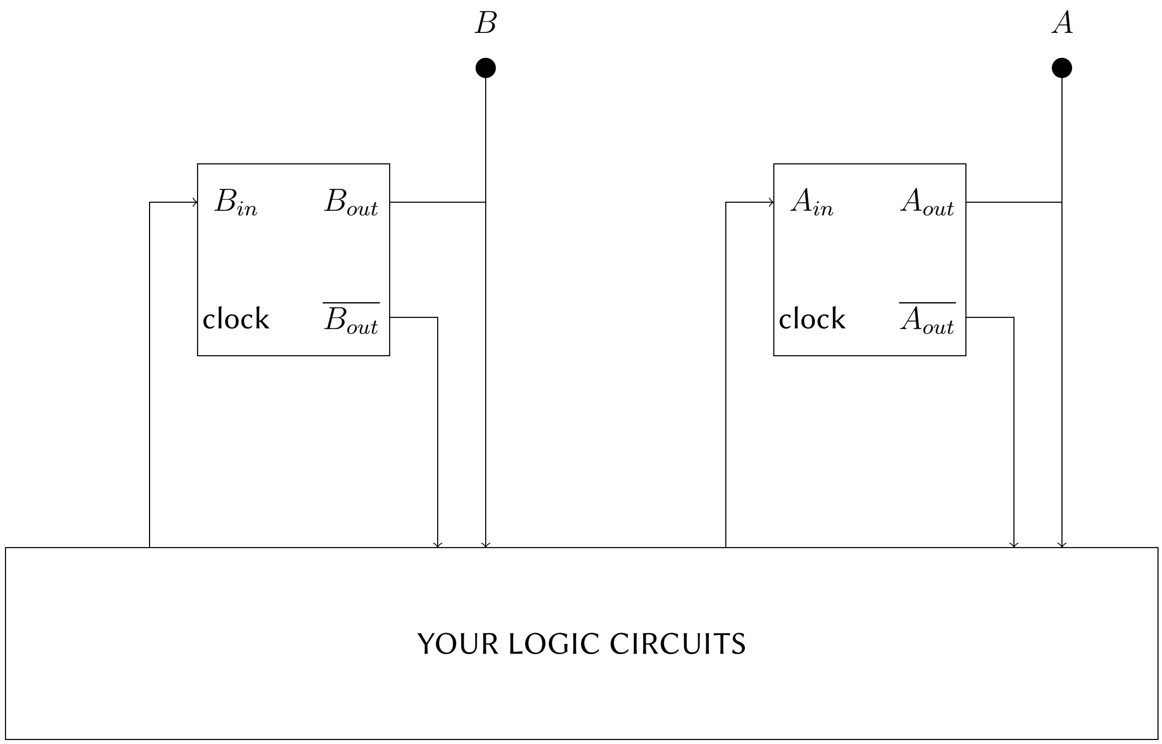


For example, if $A_{out} = 0$, A_{in} can vary between 0 and 1 but A_{out} will not change. But if $A_{in} = 1$ and a clock pulse is applied then A_{out} will change to 1 and will stay that way until a new input value and clock pulse is applied. Note that flip-flops usually provide both the latched value and its negated value as outputs.

Your assignment is to use two flip-flops to design a binary counter from 0 to 3: $00, 01, 10, 11, 00, \ldots$. Call the least significant bit A and the most significant bit B. Thus, the transitions should be as follows:

A	B
0	0
0	1
1	0
1	1
0	0

The final complete circuit looks something like this:



You need to design the two logic circuits that take the outputs of the flip-flops as inputs to set up the proper next values on the inputs so that the next sequence in the count is latched on the next clock pulse. For example, if $A_{out} = 0$ and $B_{out} = 0$, you need your logic to make sure that $A_{in} = 1$ and $B_{in} = 0$ for the next clock pulse.

Start by constructing the following truth table that shows all the inputs and outputs:

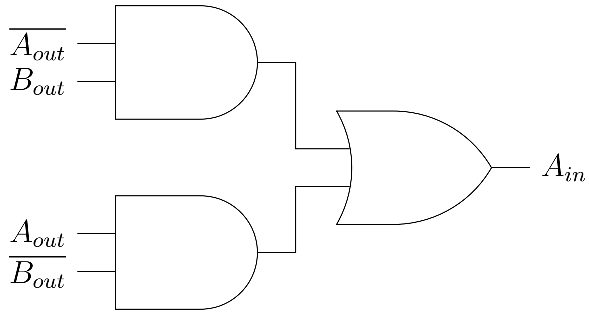
A_{out}	B_{out}	A_{in}	B_{in}
0	0	0	1
0	1	1	0
1	0	1	1
1	1	0	0

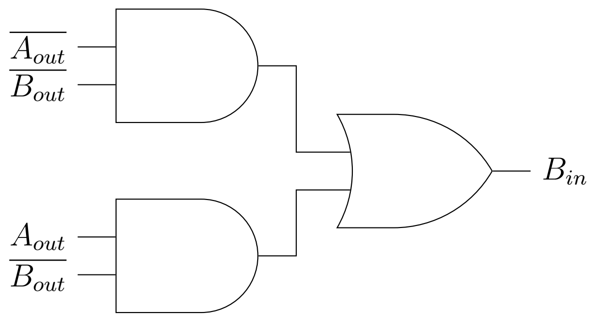
Next, determine the logic equations for A_{in} and B_{in}. And finally, draw the logic circuits for A_{in} and B_{in} similar to those in Section 1.2.6 of the textbook. Note that you only need show the two individual logic circuits and not the complete circuit as shown above.

Using the technique to find the canonical forms:

$$A_{in} = \overline{A_{out}}B_{out} + A_{out}\overline{B_{out}}$$
$$B_{in} = \overline{A_{out}}\,\overline{B_{out}} + A_{out}\overline{B_{out}}$$

The corresponding logic circuits are as follows:





This answer is acceptable; however, there is a simpler solution:

$$
\begin{aligned}
A_{in} &= A_{out} \oplus B_{out} \\
B_{in} &= \overline{B_{out}}
\end{aligned}
$$

This can be surmised directly from the truth table. Also, using the information is section 1.3 of the text:

$$
\begin{aligned}
B_{in} &= \overline{A_{out}}\,\overline{B_{out}} + A_{out}\overline{B_{out}} \\
&= \overline{B_{out}}(\overline{A_{out}} + A_{out}) \\
&= \overline{B_{out}}(T) \\
&= \overline{B_{out}}
\end{aligned}
$$

The simplified circuits are as follows: