

Microprocessor Design Bootcamp: Combinational and Sequential Logic

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December 16, 2025
Nursultan Kabylkas

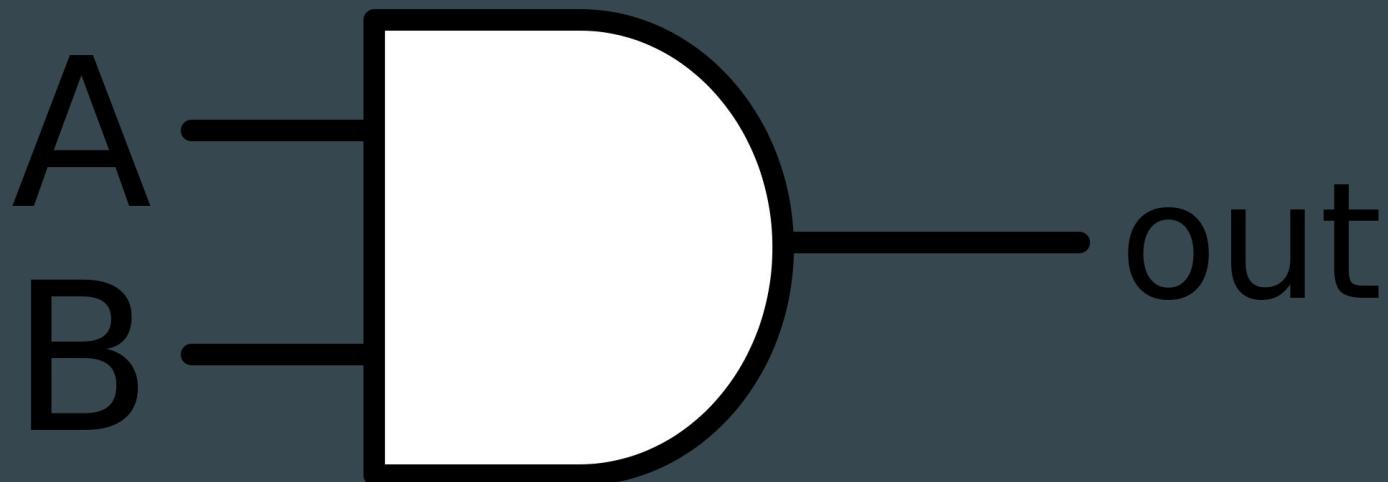
Combinational circuits

- Combinational logic is a type of digital logic where the output is a pure function of the current inputs.

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- Combinational logic is a type of digital logic where the output is a pure function of the current inputs.
- Key Point: **No memory element**; the output is determined only by the present input values.

Is this a combinational logic?



All of the circuits we built so far were COMBINATIONAL

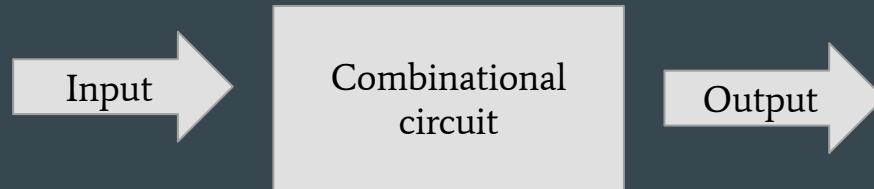
Sequential logic

- Sequential logic's output is determined by its current inputs and also prior outputs.

Combinational
circuit

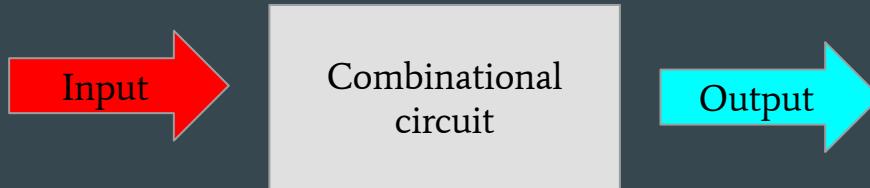
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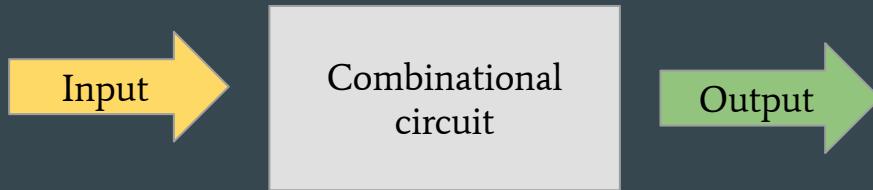
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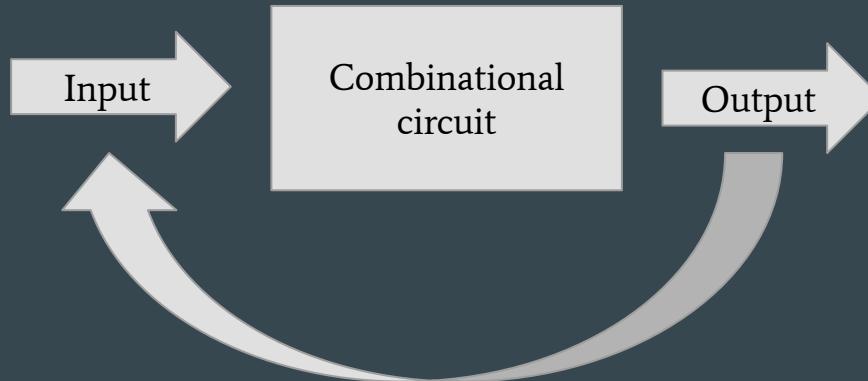
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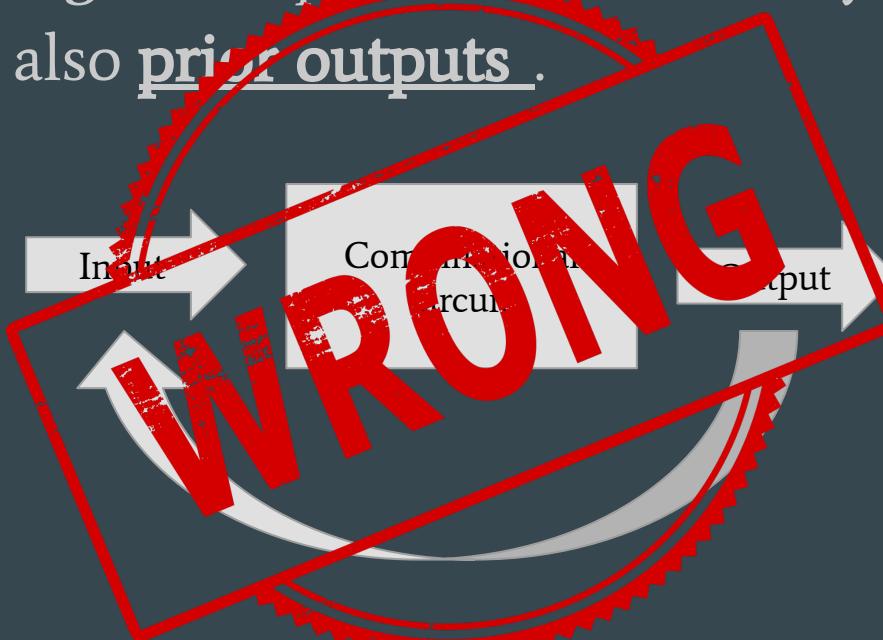
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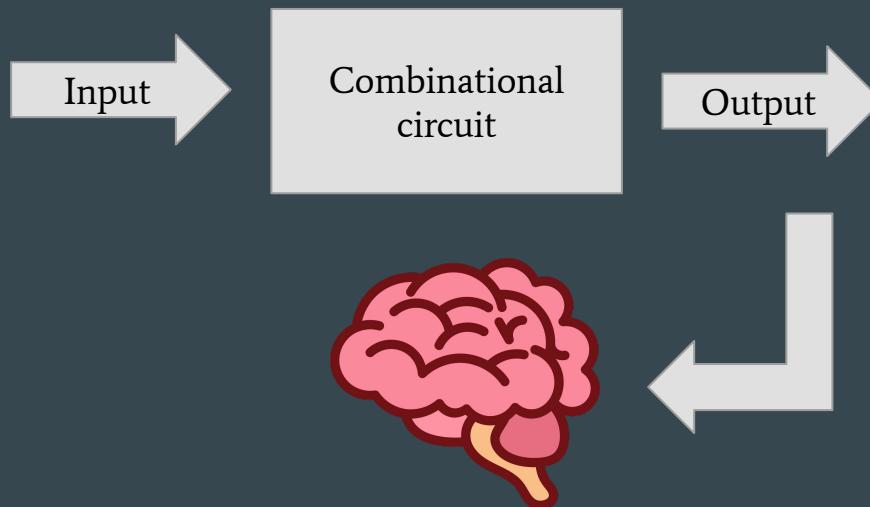
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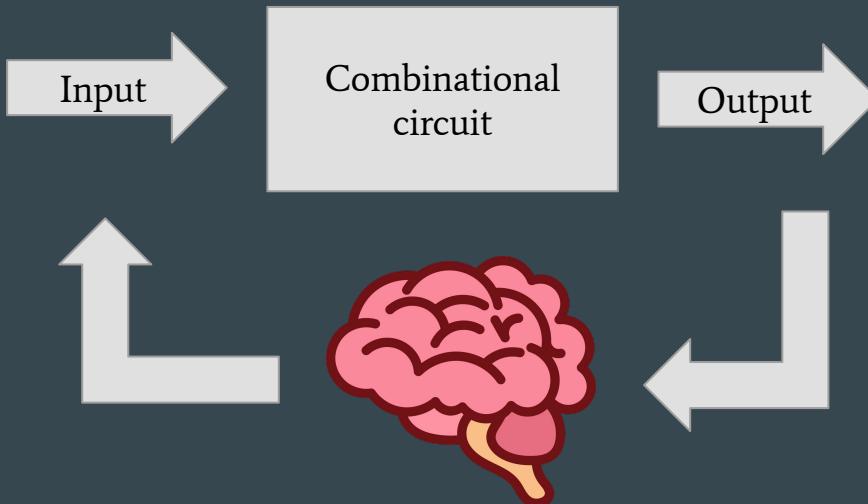
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- For the circuit to be able to “remember” prior outputs, there must be a memory element!



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How can you create a memory element with circuits?

Basic memory element: flip-flop

- Inputs D, CLK and outputs Q and Q-not.



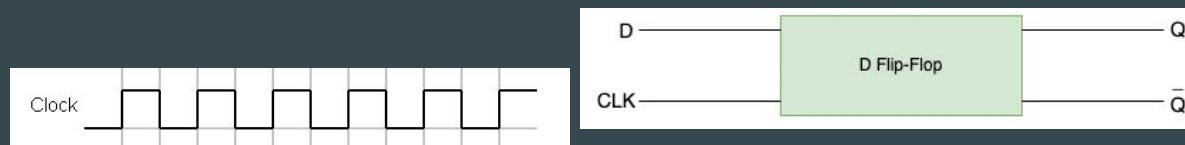
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- **Behavior of this circuit: at event CLK, save the value of D to Q.**



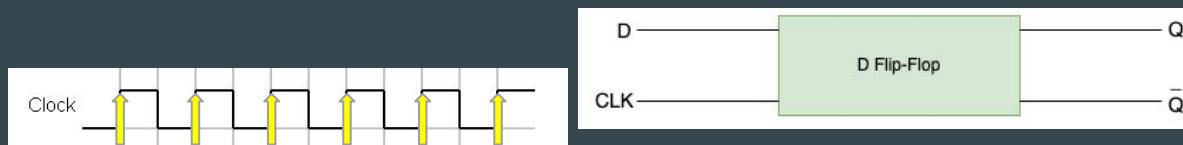
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- Clock is a periodic signal, the “save” event is the positive edge of the clock.



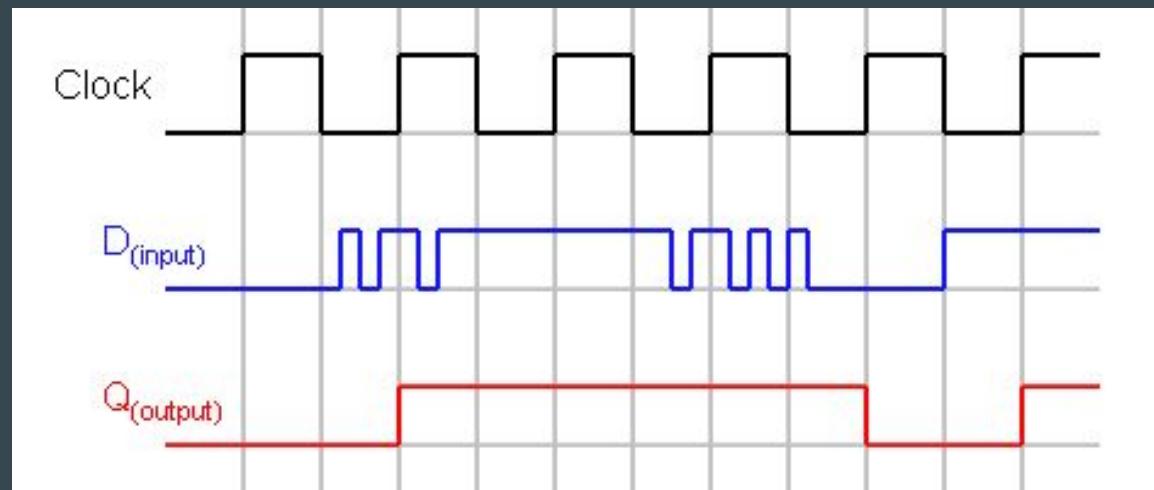
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- Positive edge means when clock goes from low to high.



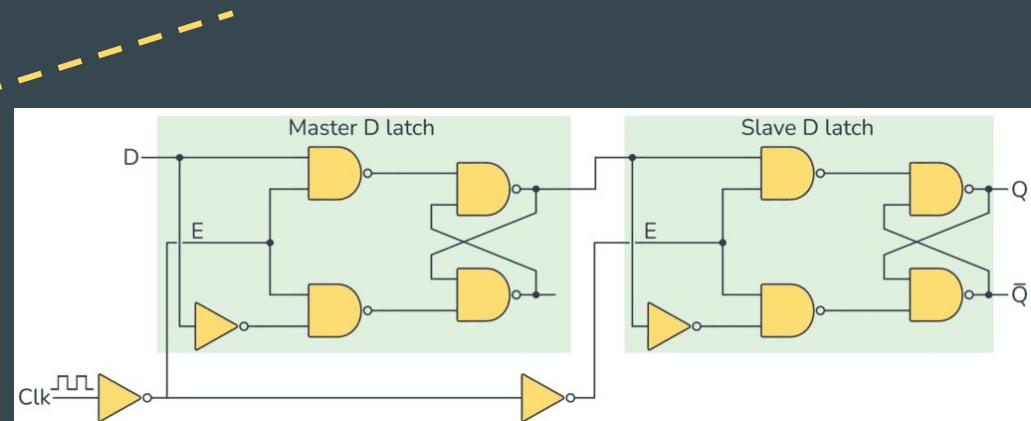
Basic memory element: flip-flop

- Flip-flop behavior: on the positive edge of clock (CLK) pass the value of D to Q.



Basic memory element: flip-flop

- What's inside the flip flop?
- Bunch of gates connected in a smart way.



Basic memory element: flip-flop

- Do we care???
- No, hail to the abstraction!



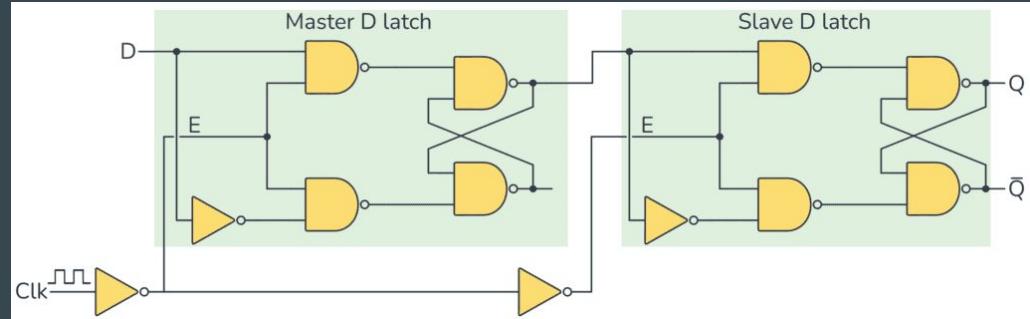
Many types of memory

- Flip-flops
- SRAM
- DRAM
- Flash
- Disk hard drive
- Tape

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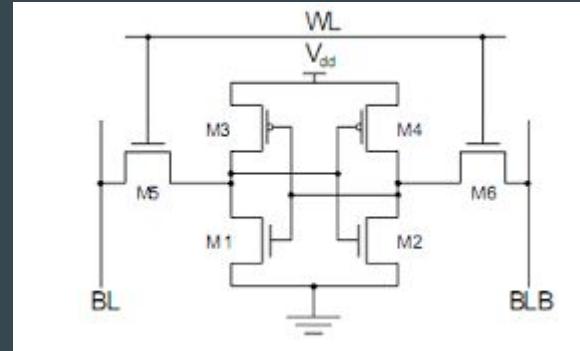
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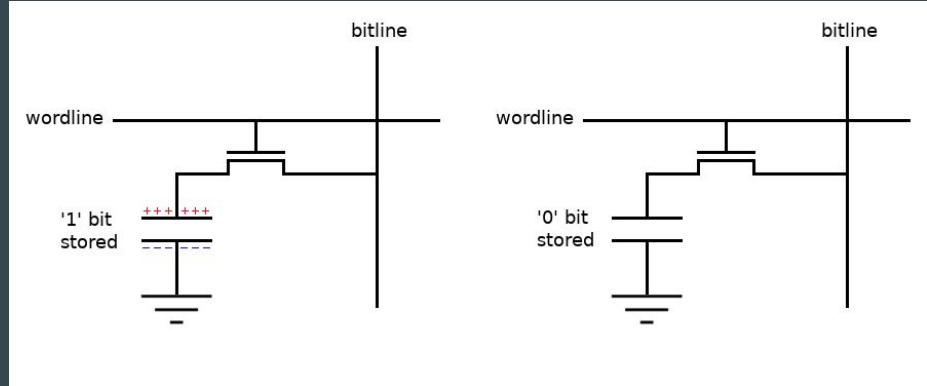
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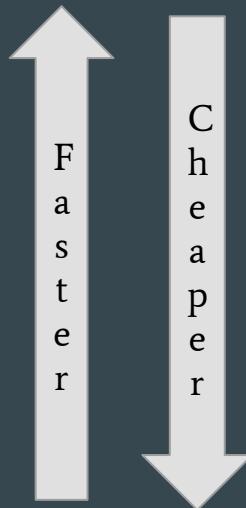
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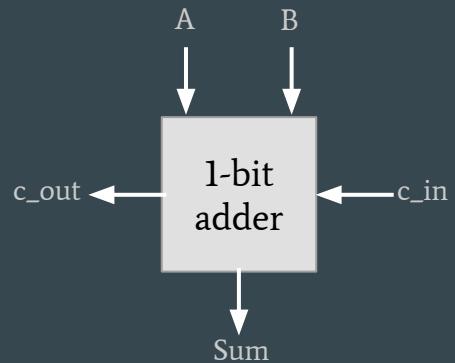
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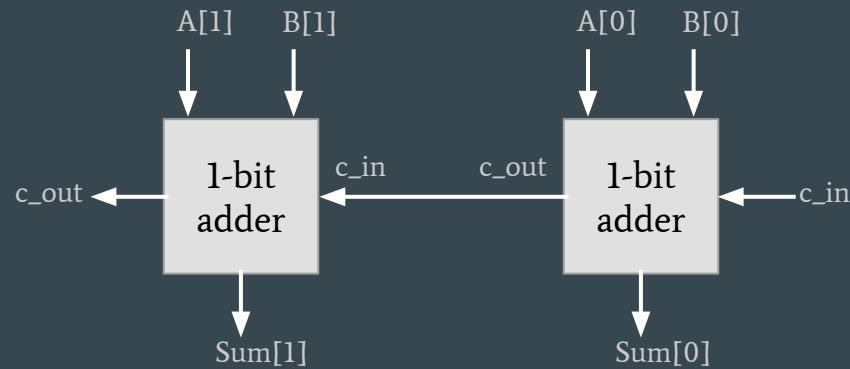


We can care about
some high level
conceptual matter.

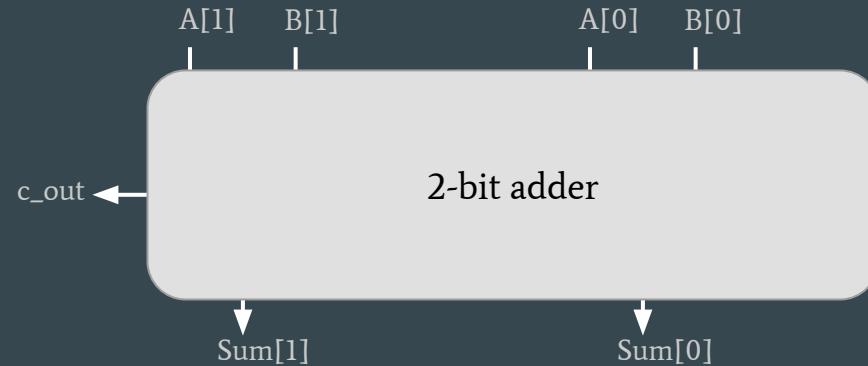
Let's build sequential logic: combinational+memory



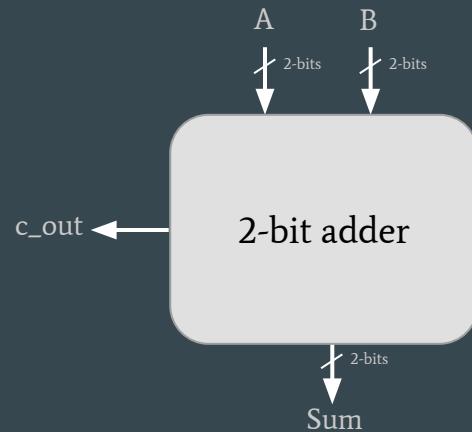
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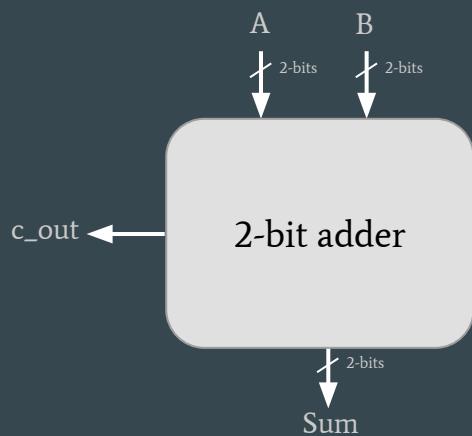


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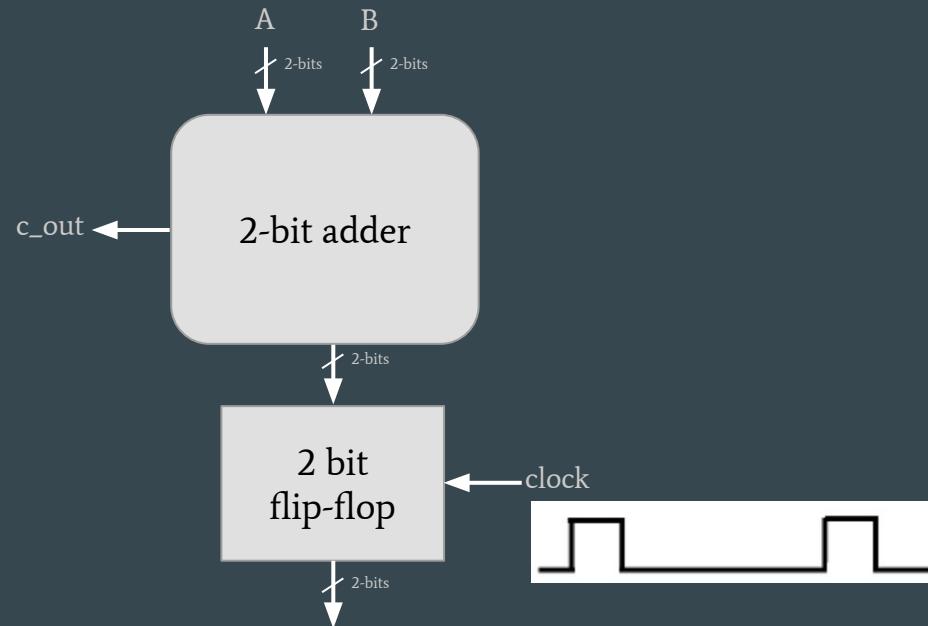


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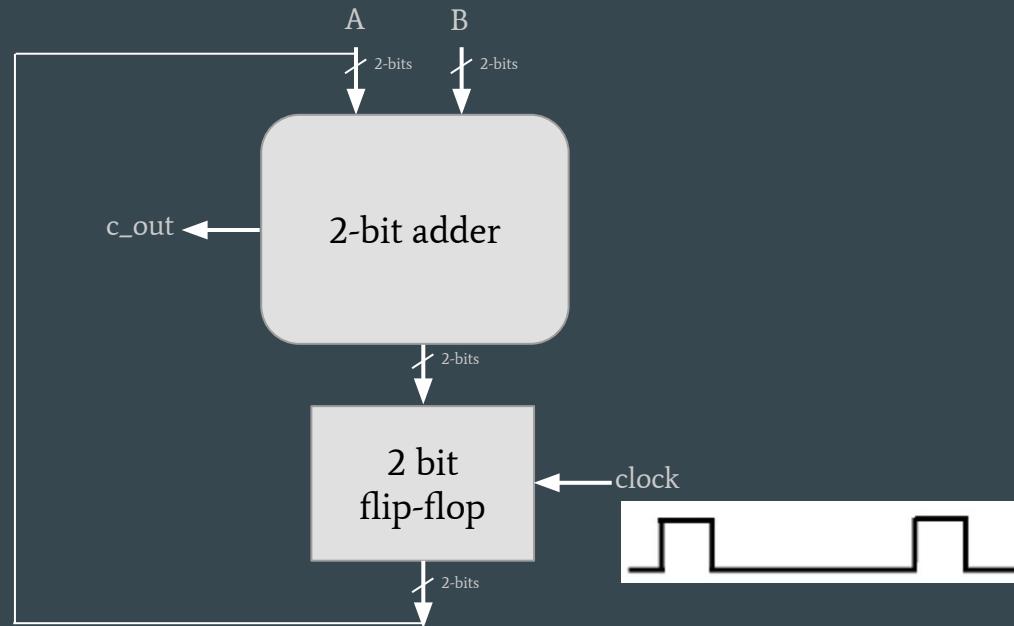
Still
combinational
logic!



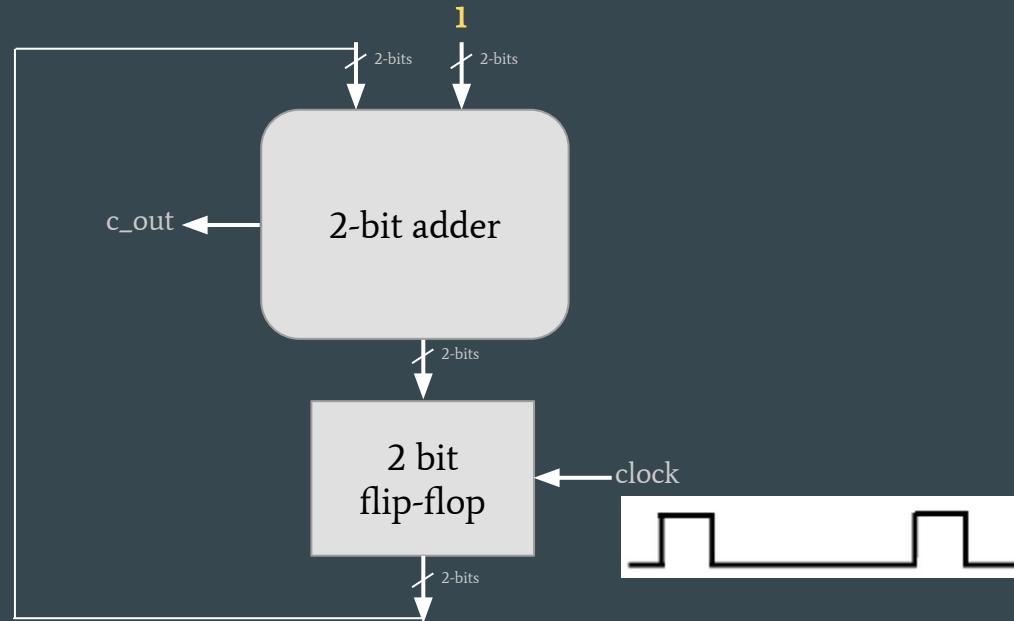
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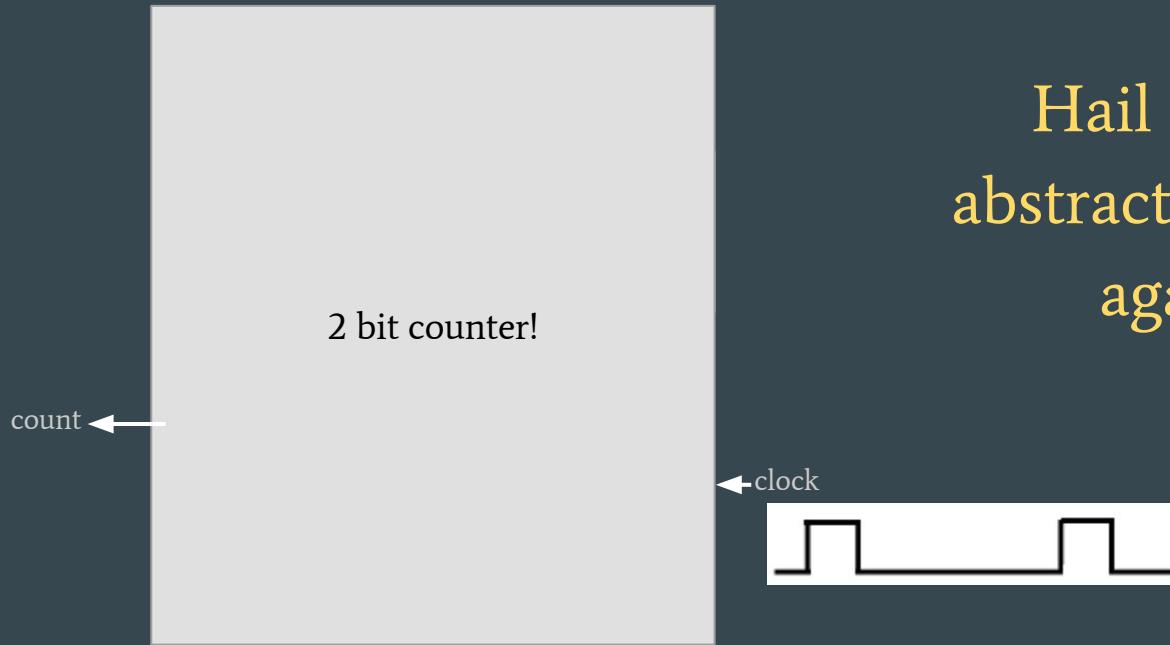
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Hail to the
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