DSM Practice Sheet 4

💡 This practice sheet intends to ensure you understand the concepts behind and functioning of memory elements like latches and Flip-Flops.

Q1

You've studied about the performance metrics of a Flip-Flop in class, namely the setup time (t_s), hold time (t_h) and propagation delay (t_{pd}). Consider a positive-edge-triggered D flip-flop as shown in *fig. 1*. Given, $t_s = 20ns,\ t_h = 5ns,\ t_{pd} = 30ns$, what is the maximum clock frequency that can be used without risk of failure? What happens if we apply a clock faster than this?

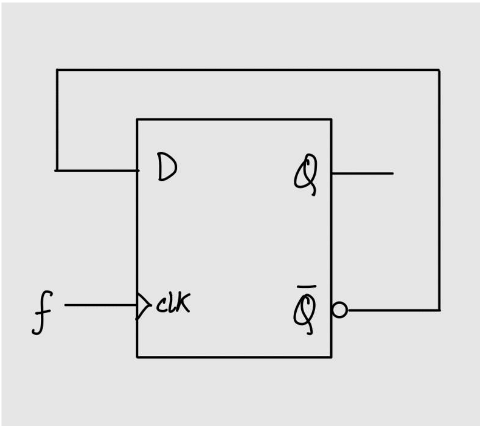

fig. 1

What specific operation does this circuit achieve?

Q2

Usually, propagation delay is considered an undesirable characteristic of logic gates, which we simply have to live with. Other times, it is a useful, even necessary, trait. In the circuit in *fig. 2*, obtain the timing diagram for the signal at the output, and identify what this circuit offers.

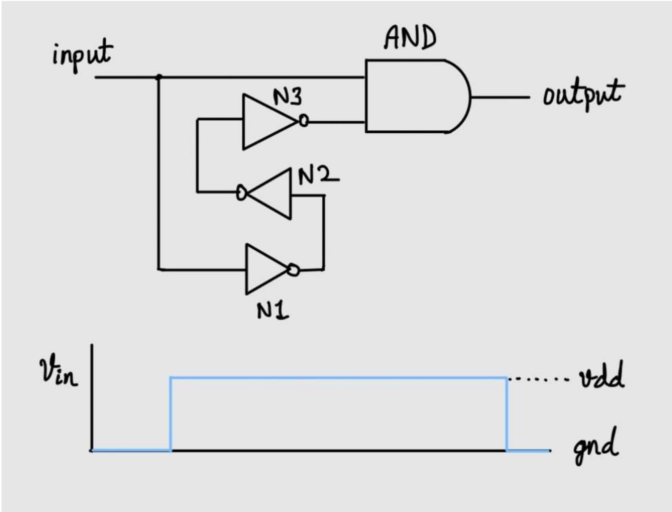

fig. 2

Next, determine the output Q for the D-latch in *fig. 3 (a)*, given the input and enable signals as shown in *fig. 3 (b)*.

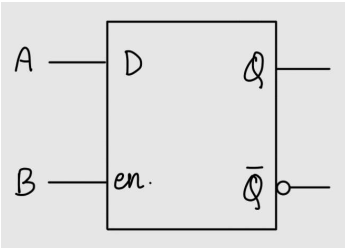

fig. 3 (a)

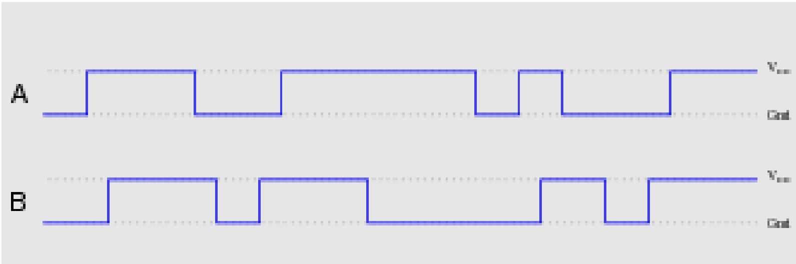

fig. 3 (b)

Now, if we add the circuit in *fig.2* to the enable input of this latch, what happens? Trace Q and identify what this latch now behaves like.

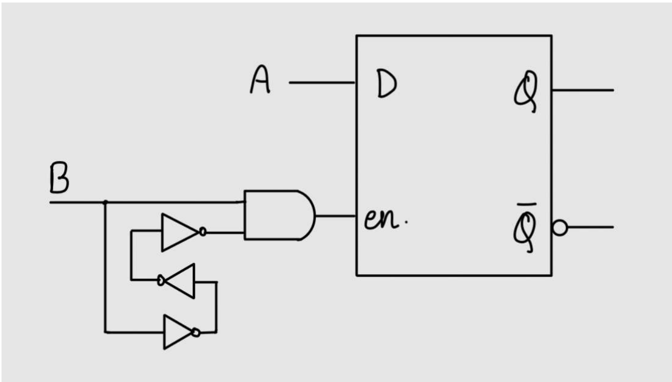

fig. 3 (c)

While we are at propagation delay, we encourage you to look up what are in general better in terms of speed (less t_{pd}) and power consumption, latches or flip-flops? Why do most of the operations prefer flip-flops?

Q3

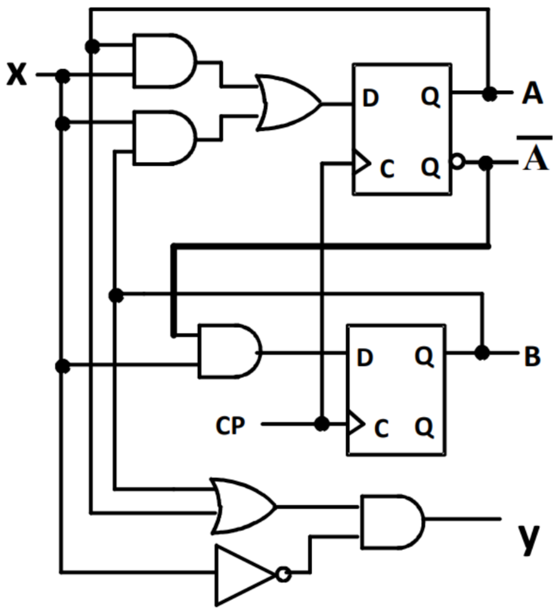

fig. 4 (a)

In the circuit shown in *fig. 4 (a)*, x is the input signal, y is the output. What is the output function and next-state function? Furthermore, complete the timing diagram from *fig. 4 (b)* to trace states A, B and output y.

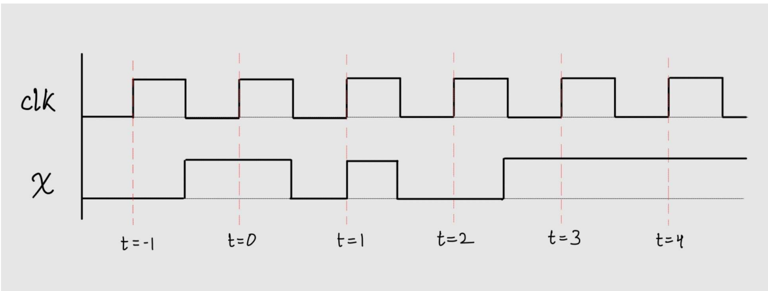

fig. 4 (b)

Q4

While vacationing in Bangalore, Ruthwik grew frustrated with the frequent traffic jams. Recognizing that a significant portion of the issue stemmed from vehicles going the wrong way, he leveraged his expertise in digital circuits and systems to propose a sensor-based alarm system. This system would alert whenever a car entered a one-way road in the wrong direction.

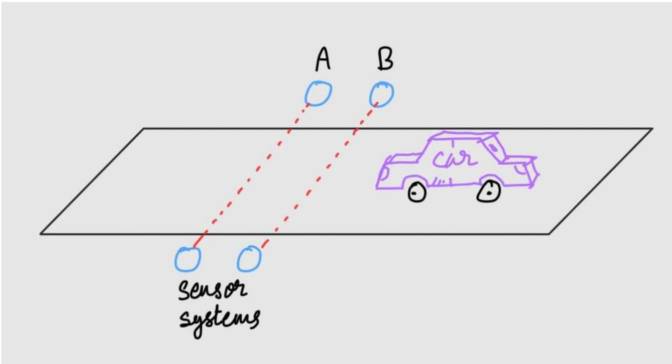

fig. 5 (a)

The sensors operate by detecting interruptions in the light beams as a vehicle moves through them. The gap between the sensors is shorter than the typical length of a car. This results in a sequence where, as a car passes through, initially one beam is interrupted, followed by both beams being interrupted, then only the final beam is interrupted, and finally, neither beam is interrupted.
When a sensor beam is interrupted, the sensor outputs logic 1, otherwise it's 0. The circuit designed to fire the alarm is shown in *fig. 5 (b)*.

- Given the situation shown in *fig. 5 (a)* identify which way is the right way on this road. (left-to-right, or right-to-left ?)
- What happens if sensor A breaks, i.e. doesn't ever go high?

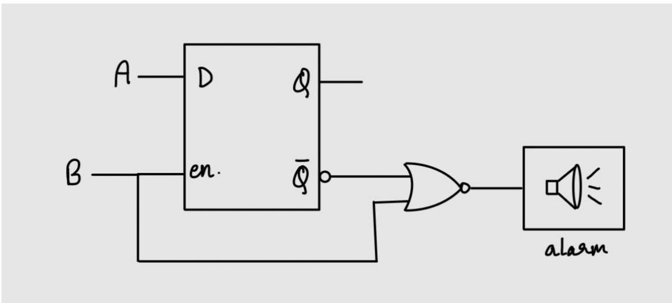

fig. 5 (b)

Q5

Create a digital logic circuit that could determine if a given binary number, presented serially, was a power of 2.

- What is the logic to identify if a binary number is a power of two?
- Design a circuit that takes in a serial input stream (MSB first), and outputs a 1 if the number represented by the input stream *so far* is a power of two, and 0 otherwise.
  (Hint: analyze the states and use flip-flops to realize a sequential circuit.)
- Your machine stops when the input *so far* is impossible to be a power of 2.
