Digital Engineering

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Lecture 10

What is an S-R Latch?

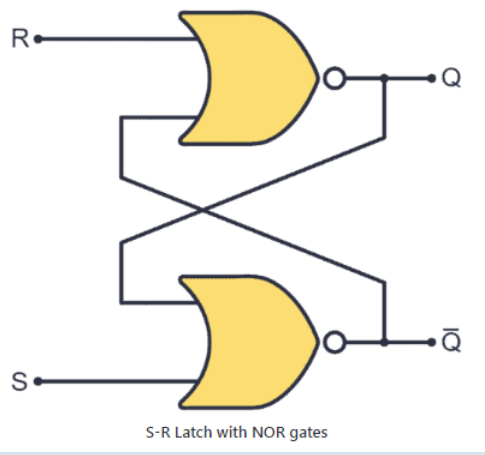
A latch

- Is an **asynchronous circuit** (it doesn't require a clock signal to work).
- Has two stable states, HIGH ("1") and LOW ("0")
- Can be used for storing binary data.
- Sequential circuits and larger storage devices, such as **shift registers**, use latches as their principal building block.

Set-Reset (S-R) latch

- The simplest latch is the *Set-Reset* (S-R) latch. You can build one by connecting two NOR gates with a cross-feedback loop.
- This feedback path is important to storing one bit of data as long as the circuit is powered.

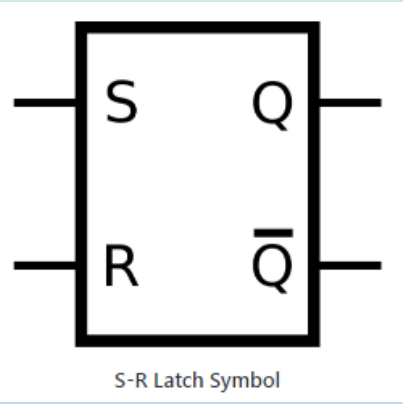
Input S	Input R	Output Q
0	0	Previous State
0	1	0
1	0	1
1	1	0 (Invalid)



S-R Latch with NOR gates

- Remember that the NOR gate only gives "1" when both inputs "0",

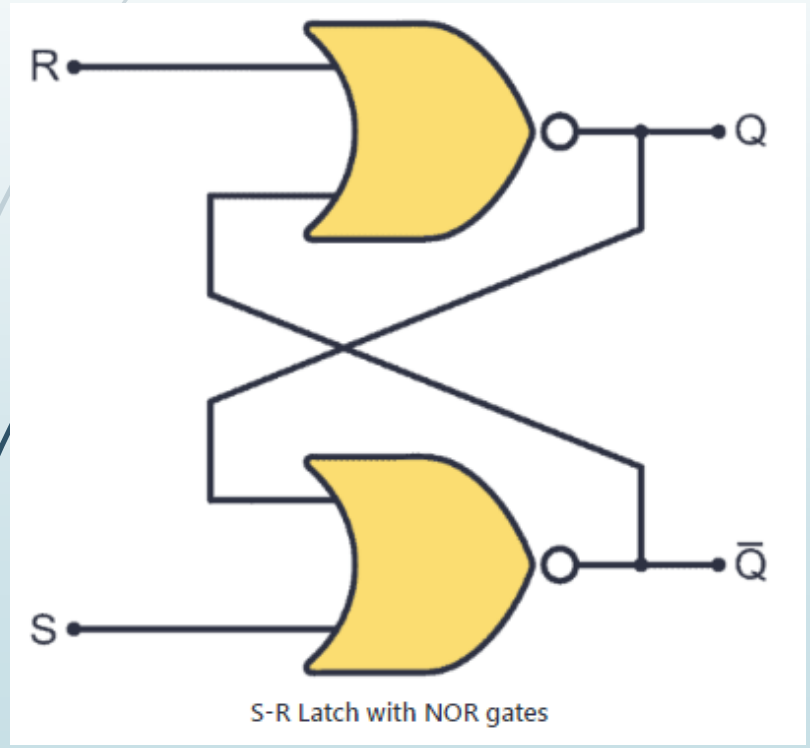
  with any other input combination the output is "0"



S-R Latch Symbol

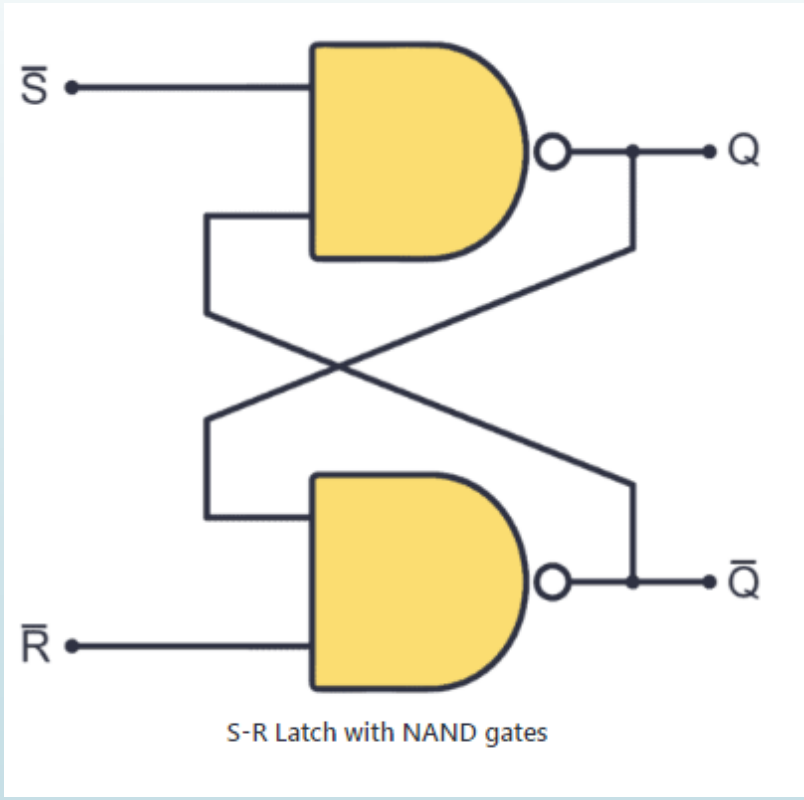
SR LATCH

The S-R Latch can also be built two NOR gates with a cross-feedback loop.



S-R Latch with NOR gates

The S-R Latch can also be built using two NAND gates with a cross-feedback loop

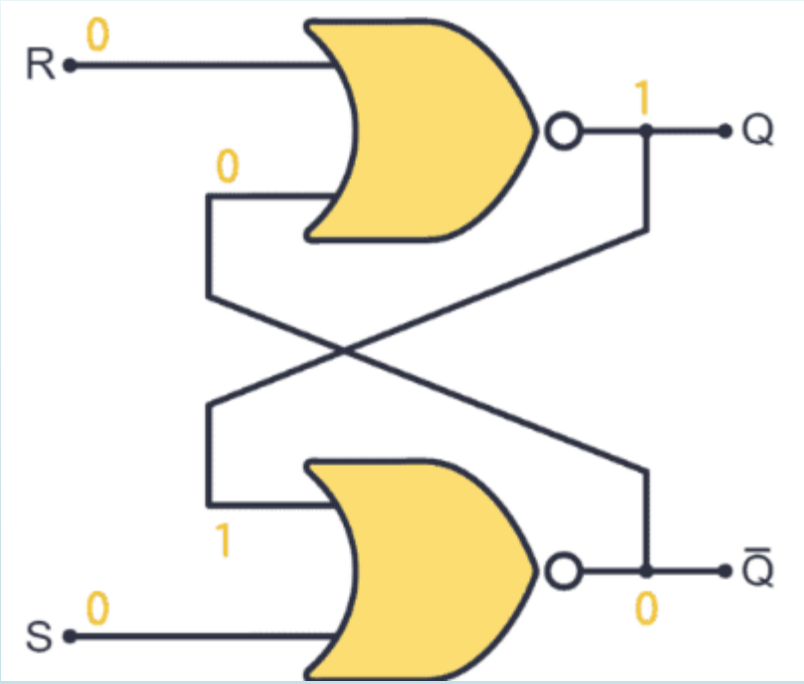


S-R Latch with NAND gates

How SR LATCH works?

Suppose the Q output is “1” in the present state.

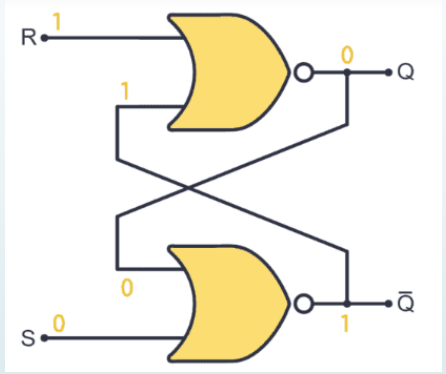
- If you now place both inputs in “0”, then the output will remain “1” as follows:
- This is the memory function of the S-R latch because it saves the previous value.



How to reset the SR LATCH?

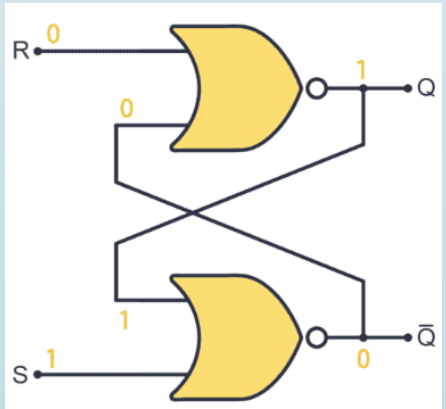
- *HOW TO "Reset" the Q output to "0"?*

  as you can see in the truth table, you need a "1" in the R input and a "0" in the S input.



Input S	Input R	Output Q
0	0	Previous State
0	1	0
1	0	1
1	1	0 (Invalid)

But, if you want to "*Set*" a "1" in the Q output just follow the truth table and place a "1" in the S input and a "0" in the R input.



WHEN S=1 , R=1, Q and Q' both are 0!!! INVALID STATE

- Finally, the S and R inputs should never be "1" at the same time because the NOR gate only gives "1" when both of its inputs are "0", but if one input is "1", then the output will be "0".
- As a result, if S and R are "1", both latches' outputs will be **"0" at the same time**, something **that violates this latch's working principle.**

Input S	Input R	Output Q
0	0	Previous State
0	1	0
1	0	1
1	1	0 (Invalid)

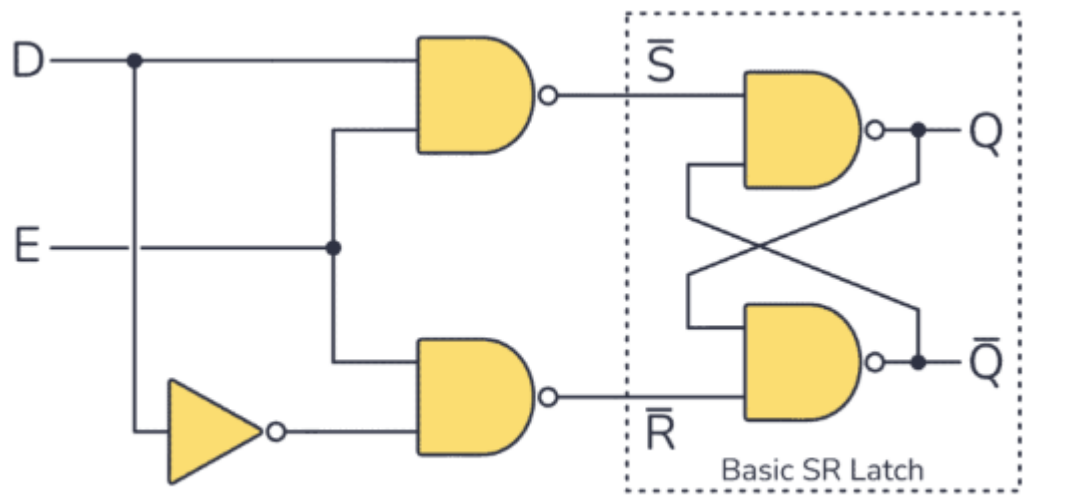
what is D latch

- The D Latch is a logic circuit most frequently used **for storing data in digital systems.**
- It is based on the S-R latch, **but it doesn't have an "undefined" or "invalid" state problem**.

- A **D latch** can store a bit value, either 1 or 0. When its Enable pin is HIGH, the value on the **D pin** will be stored on **the Q output.**
- It builds upon the design of the **S-R latch**, with a few added **logic gates**.

D Latch circuit

You can see a D Latch circuit based on the S-R latch built with **NAND gates** below:



D Latch Circuit

Applications of Latches

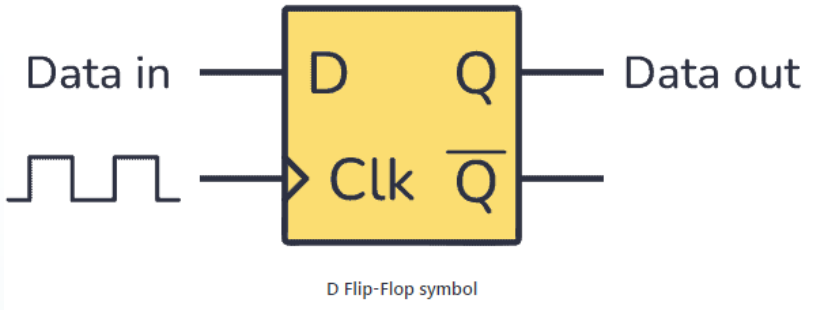
- The latches find several applications in the field of digital electronics. They are most elementary storage components used to store one bit of information in digital systems.
- Latches are used as 1-bit memory element in digital systems.
- Latches are used to design digital registers which are employed for storage and manipulation of data in microprocessors and microcontrollers.
- Latches are used to design flip-flops which are basically the synchronized latches.
- Latches are also used in communication systems for temporary data storage or buffering purposes.

What's the Difference Between Latch and Flip Flop?

- The terms *latch* and *flip flop* both can store a bit (1 or 0) at their outputs.
- While a *latch* can change its output at any time as long as it's enabled
- a *flip flop* is an edge-triggered device that needs a clock transition to change its output.

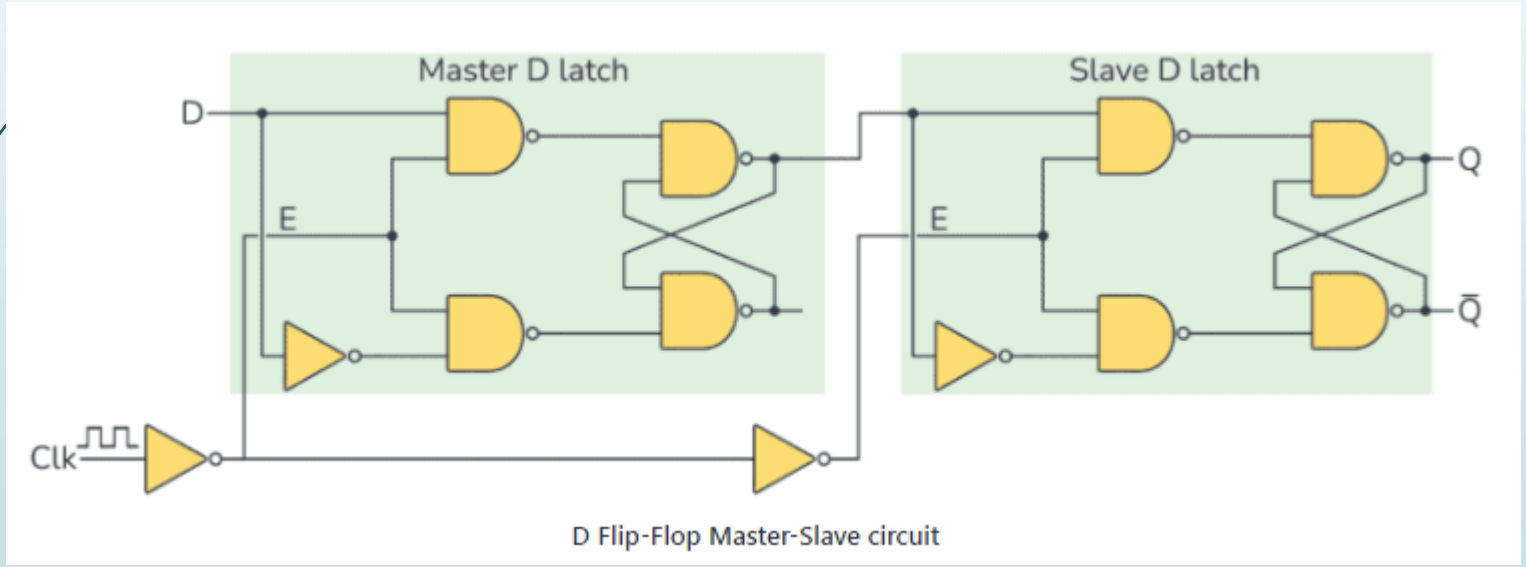
The D Flip-Flop

- The D Flip-Flop is an edge-triggered circuit that combines a pair of D latches to store one bit.
- a basic building block in digital electronics to create counters or memory blocks such as shift registers.
- flip-flops are ***synchronous* circuits** that need **a clock signal (Clk**).
- The D Flip-Flop will only store a new value from the D input when the clock goes from 0 to 1 (rising edge) or 1 to 0 (falling edge).



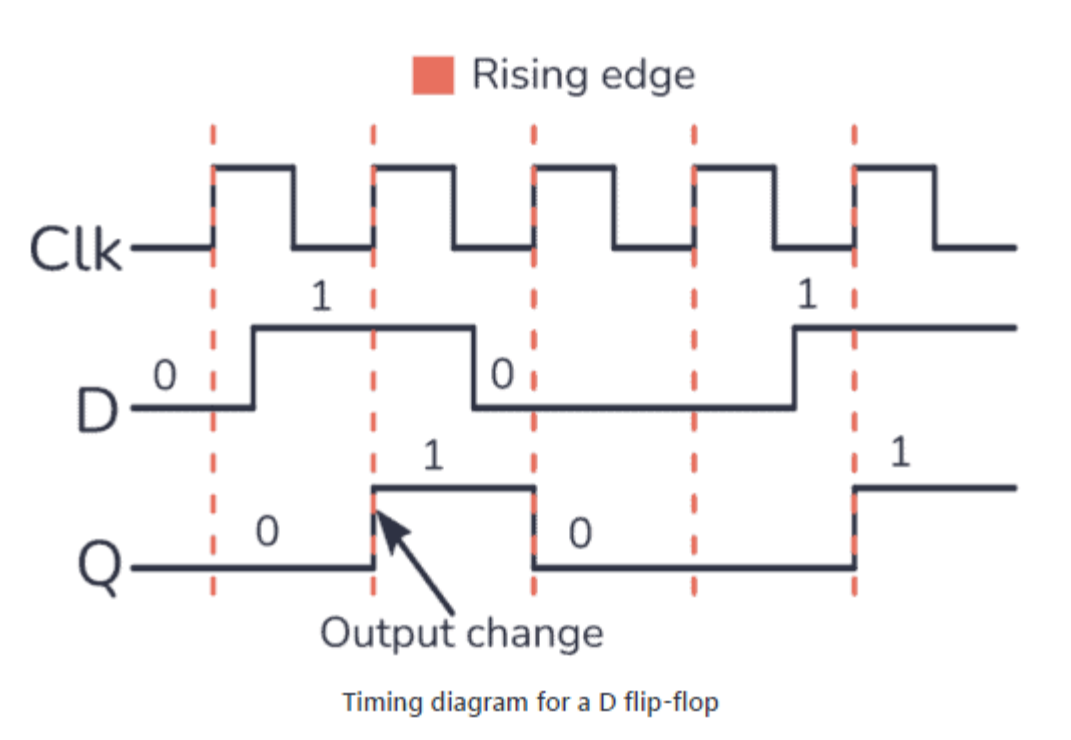
D Flip-Flop symbol

A D Flip-Flop is built from **two D latches.**

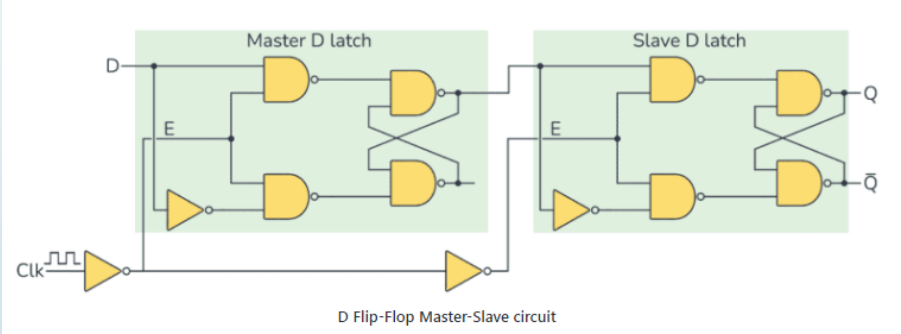


D Flip-Flop Master-Slave circuit

- The output Q only changes to the value the D input has at the moment the clock goes from 0 to 1.

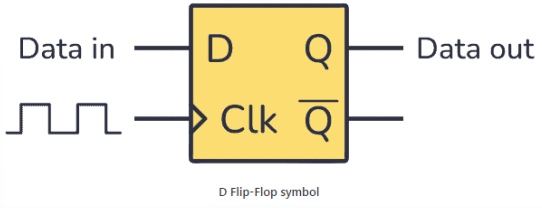


Timing diagram for a D flip-flop



D Flip-Flop Master-Slave circuit

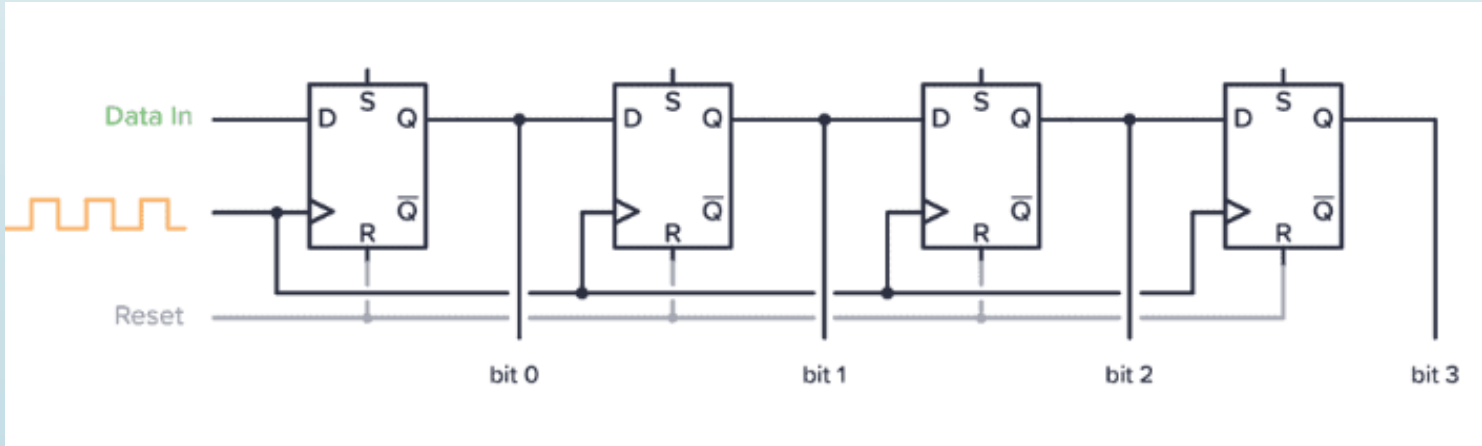
What Can You Use Them For?



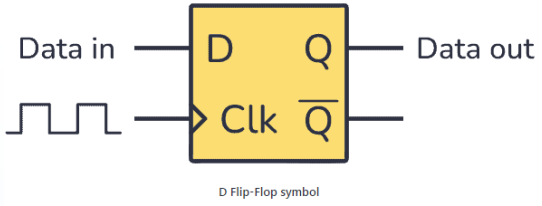
- The D Flip-flop is a very useful circuit. You can combine several D flip-flops to create for example shift registers and counters.

Circuit Example: Shift Registers

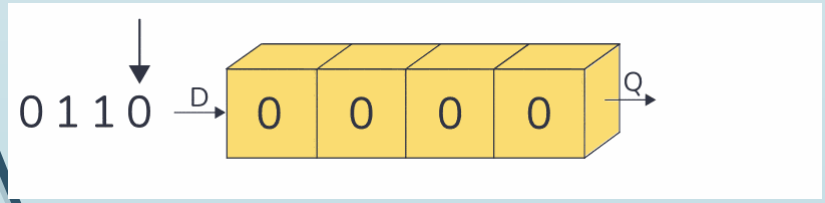
- To create a shift register, connect the output of one flip-flop to the input of the next. New bits go into the first flip-flop on the left. And for every clock pulse, the bits stored in the other flip-flops are shifted one place to the right.

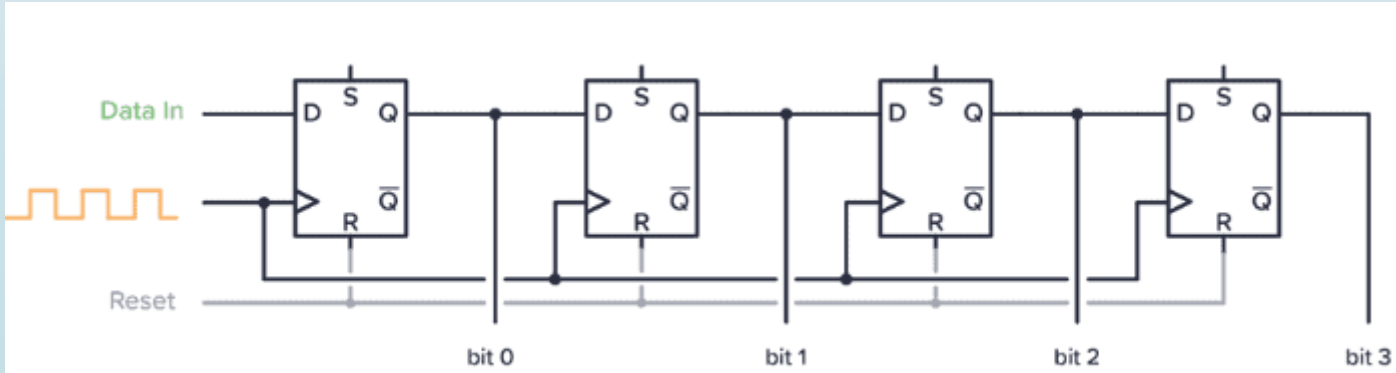


Shift register



- A shift register is a common building block in digital electronics that is used to store and move bits,
- What is a shift register used for? A shift register is commonly used in data storage, data movement, and data manipulation.
- The number of bits you can store in a shift register is equal to the number of flip-flops used.
- To create a shift register, connect the output of one flip-flop to the input of the next. New bits go into the first flip-flop on the left. And for every clock pulse, the bits stored in the other flip-flops are shifted one place to the right.





Shift register Applications

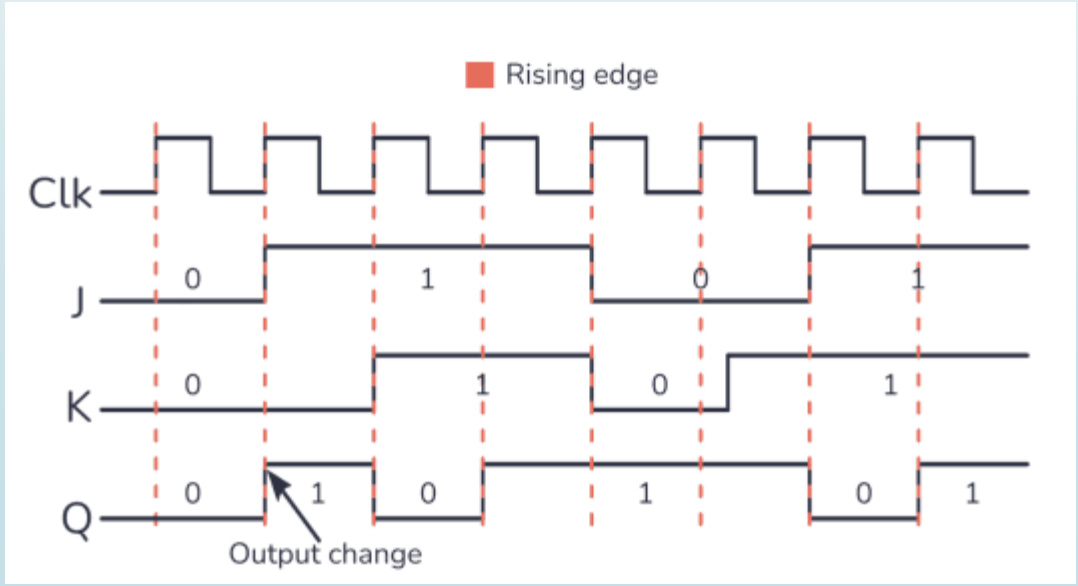
- Shift register is used as **Parallel to serial converter**, which converts the parallel data into serial data. It is utilized at the transmitter section after Analog to Digital Converter (ADC) block.
- Shift register is used as **Serial to parallel converter**, which converts the serial data into parallel data. It is utilized at the receiver section before Digital to Analog Converter (DAC) block.
- Shift register along with some additional gate(s) generate the sequence of zeros and ones. Hence, it is used as **sequence generator**.
- Shift registers are also used as **counters**.

The JK Flip-Flop

- Flip-flops are components that can store a digital value on their output. They have a Clock input (Clk) which determines when they can change the state of their output.
- The JK Flip-Flop is a type of flip-flop that can be set, reset, and toggled. It can be used for making counters, event detectors, frequency dividers.
- **Toggle** means that switching in the output instantly i.e. Q=0, Q'=1 will immediately change to Q=1 and Q'=0 and this continuation keeps on changing. 0-1-0-1-0-1-0-1……

The JK Flip-Flop

- The J and K inputs of the JK flip-flop can be used to set, reset, or toggle the output, like this:
- J=0 and K=0, the output Q (memory no change)
- J=1 and K=0 sets the output to 1
- J=0 and K=1 reset the output to 0
- J=1 and K=1 toggle the output
- **But for the flip-flop to make any change, its Clock input must be 1.**



Binary counter

- a **binary counter** is a type of **sequential logic circuit** which is able to count in binary numbers.
- The binary counters are built up of flip flops, where a flip flop is a most elementary memory element that can store 1-bit of information.
- In a binary counter, each flip flop represents one bit of the binary number. The counter increases its count by one whenever a clock pulse occurs.

Applications of Binary Counters

- Binary counters are used in numerous digital systems.
- Binary counters are used in digital clocks and other digital timing devices.
- Binary counter can be used as a frequency divider, where it divides the frequency of the input signal by a fixed value.
- Binary counter can also be used as a shift register.
- In digital systems like computers, binary counters can be used as memory address decoders.
- Binary counter can also be used as a sequence generator, where it can generate sequences of binary codes.
- Binary counters can be used in error detection and correction applications.