Unit IV

Introduction to Sequential Logic Circuits

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Sequential Circuits

- **Combinational**
  - The outputs depend only on the current input values
  - It uses only logic gates
- **Sequential**
  - The outputs depend on the current and past input values
  - It uses logic gates and storage elements
  - Example
    - ✓ Vending machine
  - They are referred as finite state machines since they have a finite number of states

Block Diagram

- **Memory elements can store binary information**
  - **This information at any given time determines the state of the circuit at that time**

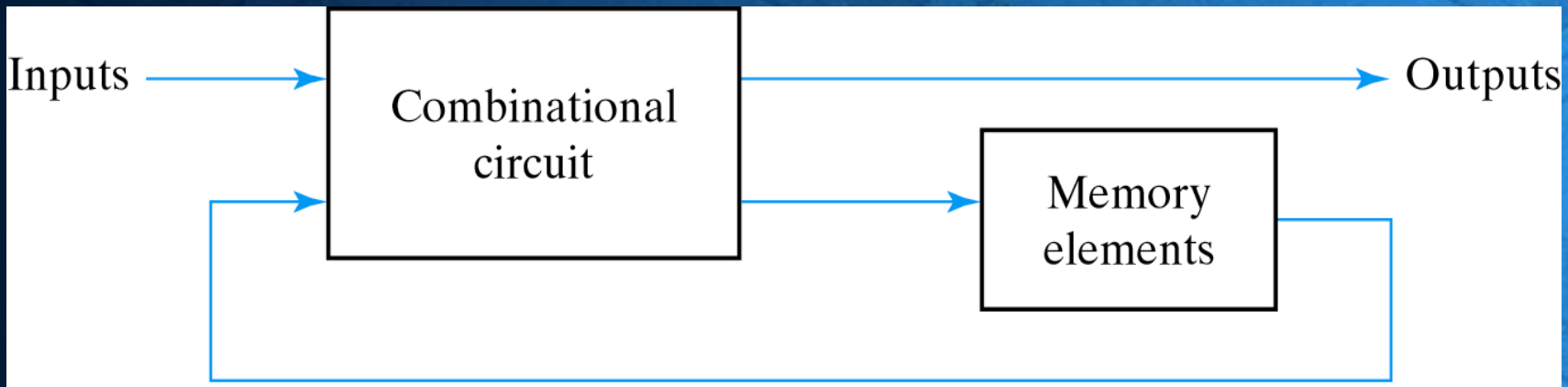


Fig. 5-1 Block Diagram of Sequential Circuit

Sequential Circuit Types

- **Synchronous**
  - The circuit behavior is determined by the signals at discrete instants of time
  - The memory elements are affected only at discrete instants of time
  - A clock is used for synchronization
    - ✓ Memory elements are affected only with the arrival of a clock pulse
    - ✓ If memory elements use clock pulses in their inputs, the circuit is called
      - Clocked sequential circuit

Sequential Circuit Types

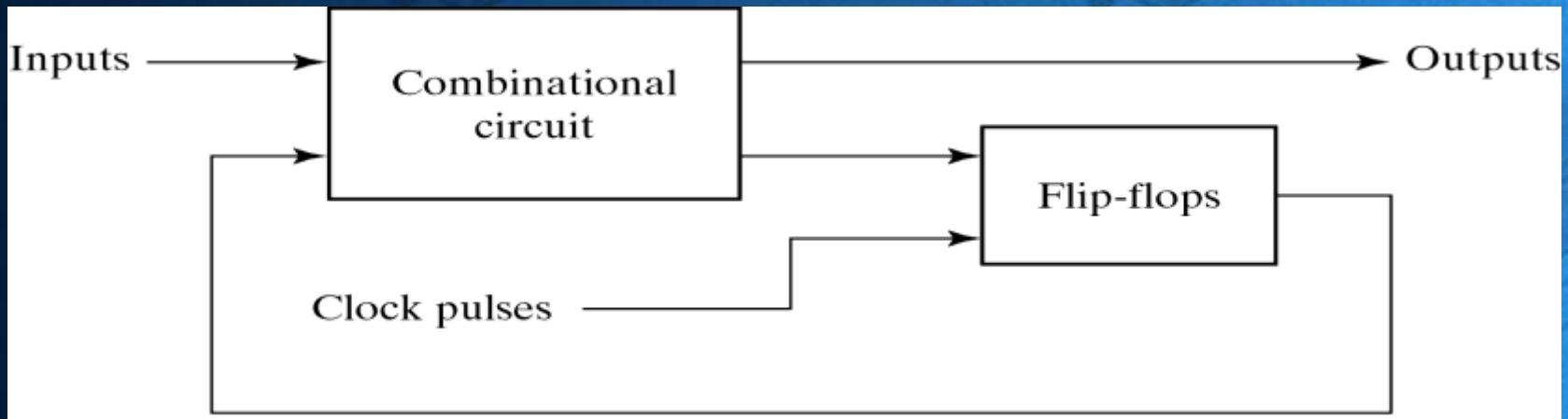
- **ASynchronous**
  - **The circuit behavior is determined by the signals at any instant of time**
  - **It is also affected by the order the inputs change**

Clock

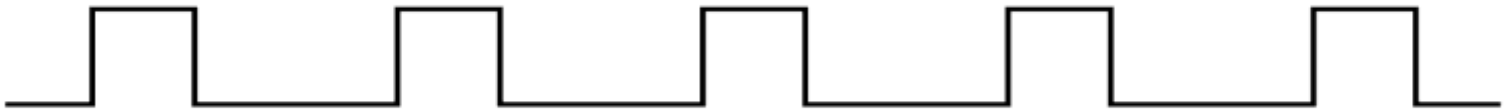
- It emits a series of pulses with a precise pulse width and precise interval between consecutive pulses
- Timing interval between the corresponding edges of two consecutive pulses is known as the clock cycle time, or period

Flip-Flops

- They are memory elements
- They can store binary information



(a) Block diagram



(b) Timing diagram of clock pulses

Fig. 5-2 Synchronous Clocked Sequential Circuit

Flip-Flops

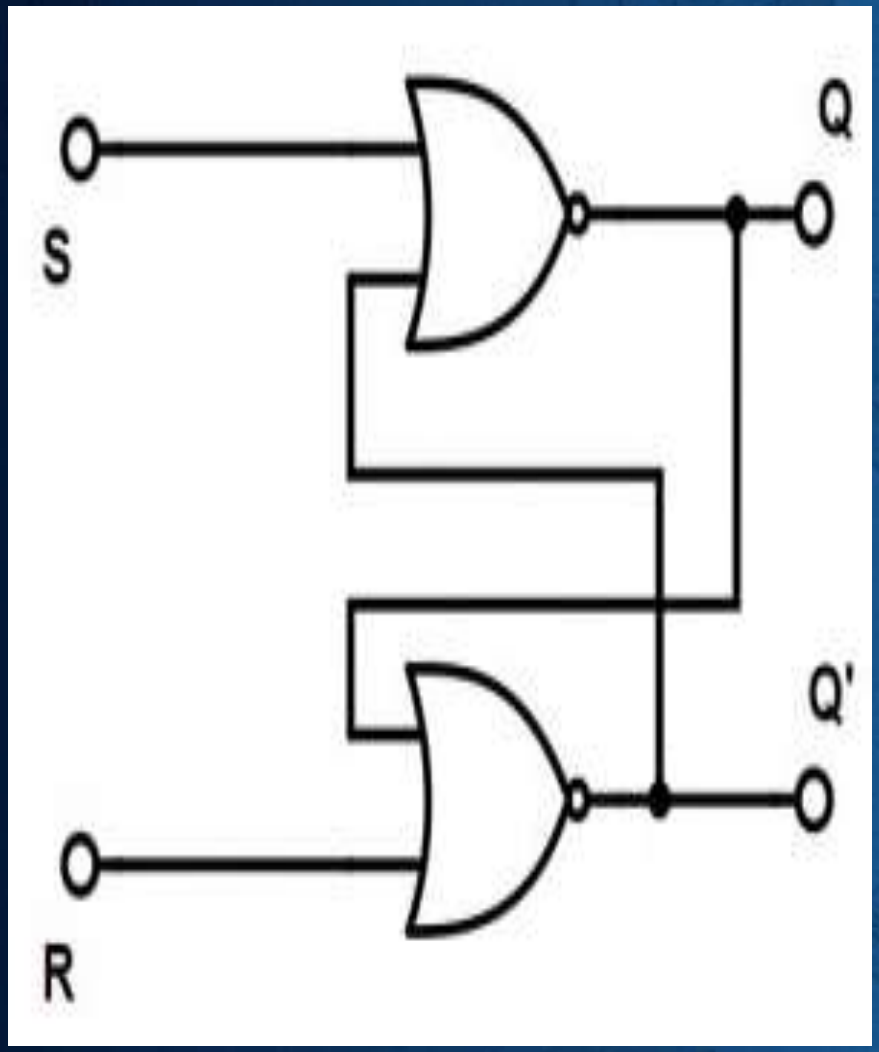
- Can keep a binary state until an input signal to switch the state is received
- There are different types of flip-flops depending on the number of inputs and how the inputs affect the binary state

Latches

- The most basic flip-flops
  - They operate with signal levels
- The flip-flops are constructed from latches
- They are not useful for synchronous sequential circuits
- They are useful for asynchronous sequential circuits

- The difference between a latch and a flip-flop is that a latch is level-triggered (outputs can change as soon as the inputs changes) and Flip-Flop is edge-triggered (only changes state when a control signal goes from high to low or low to high).

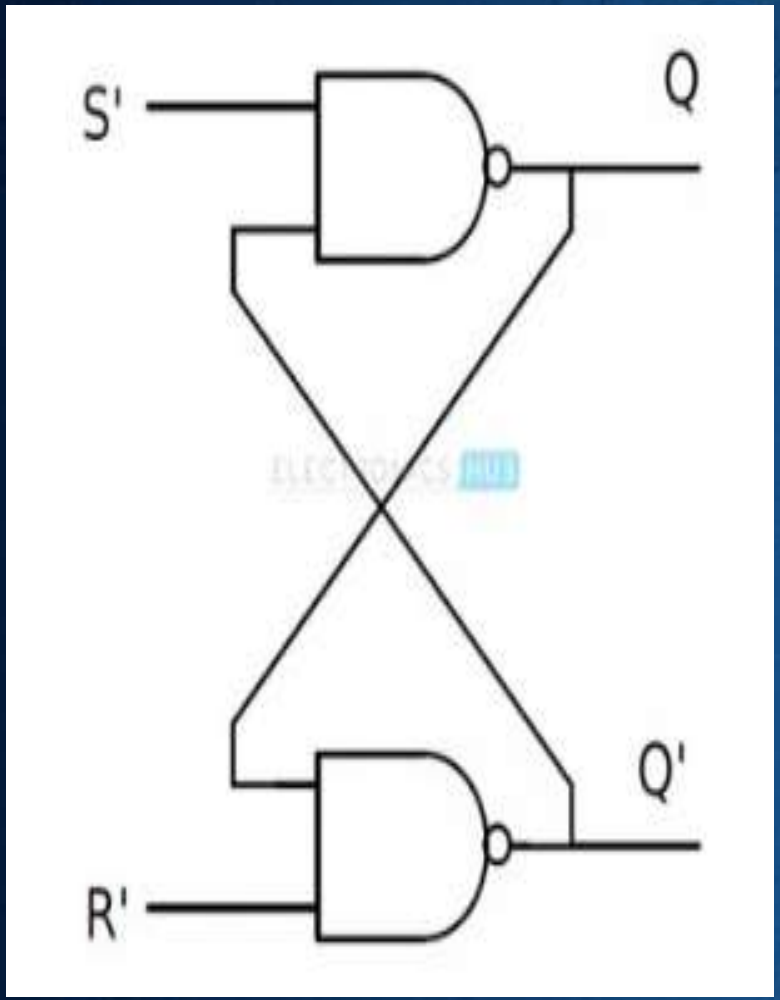
SR Latch with NOR



Input		Output
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

S	R	Q	State
0	0	Previous State	No change
0	1	0	Reset
1	0	1	Set
1	1	?	Forbidden

SR Latch with NAND



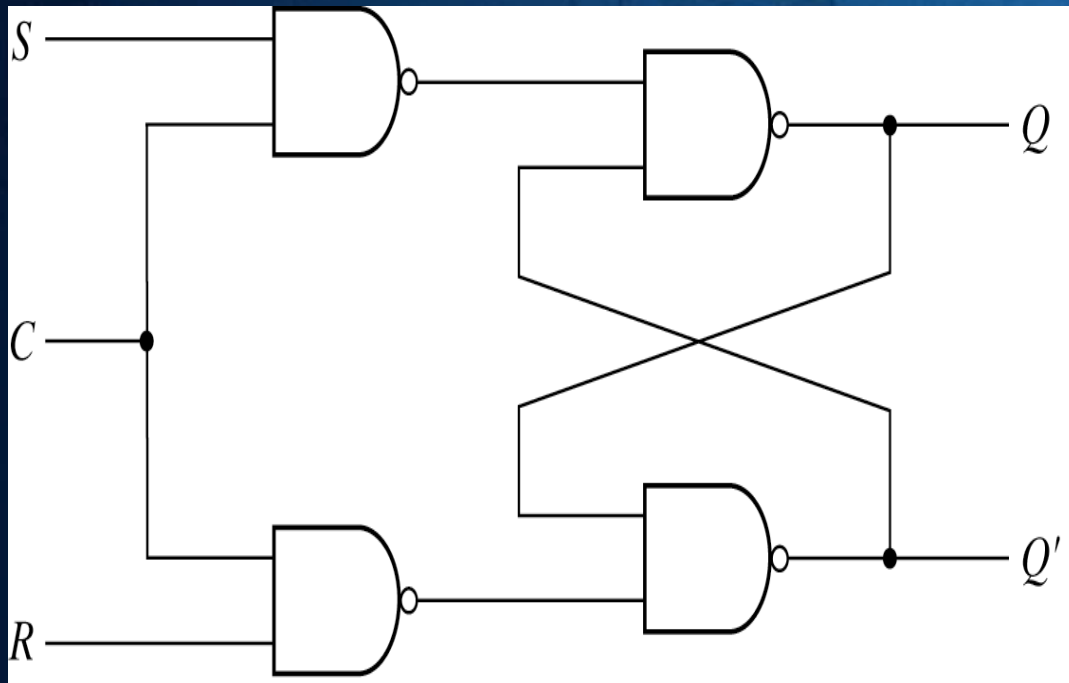
Inputs		output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

$\bar{S}$	$\bar{R}$	Q	State
1	1	Previous State	No change
1	0	0	Reset
0	1	1	Set
0	0	?	Forbidden

Link

- https://www.youtube.com/watch?v=kt8d3CYWGH4

SR Latch with Control Input



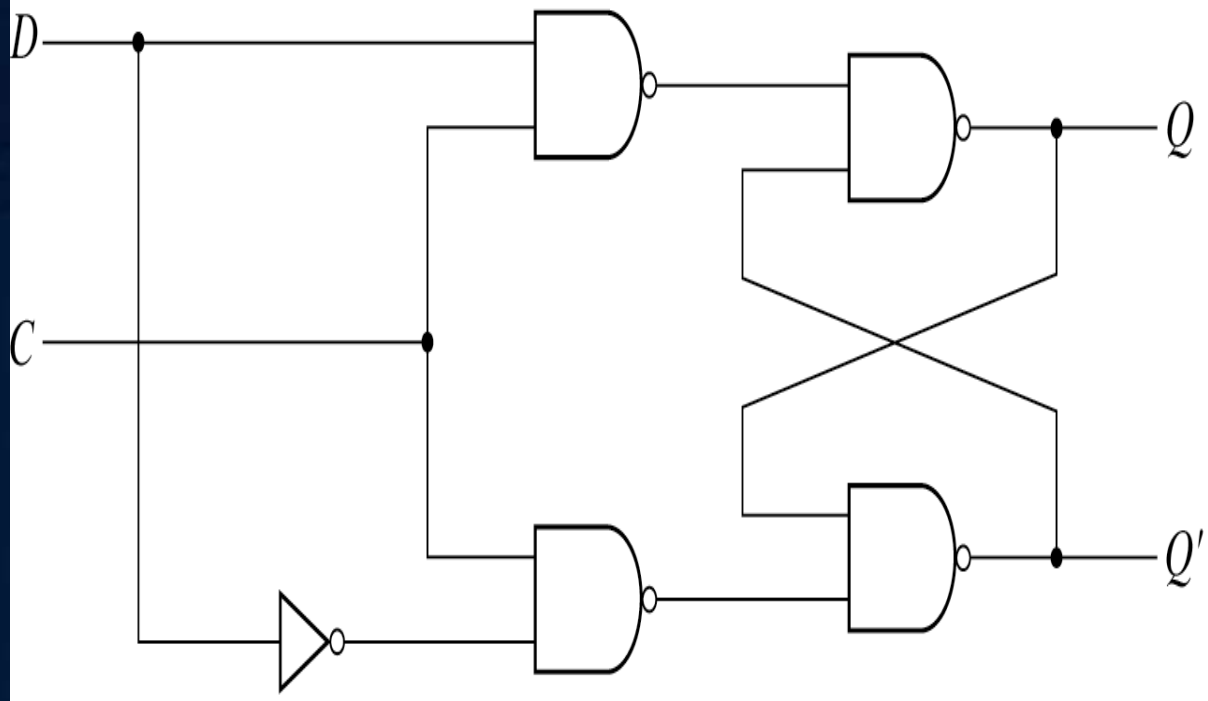
(a) Logic diagram

C	S	R	Next state of Q
0	X	X	No change
1	0	0	No change
1	0	1	Q = 0; Reset state
1	1	0	Q = 1; set state
1	1	1	Indeterminate

(b) Function table

Fig. 5-5 SR Latch with Control Input

D Latch



(a) Logic diagram

C	D	Next state of Q
0	X	No change
1	0	Q = 0; Reset state
1	1	Q = 1; Set state

(b) Function table

Fig. 5-6 D Latch

Symbols for Latches

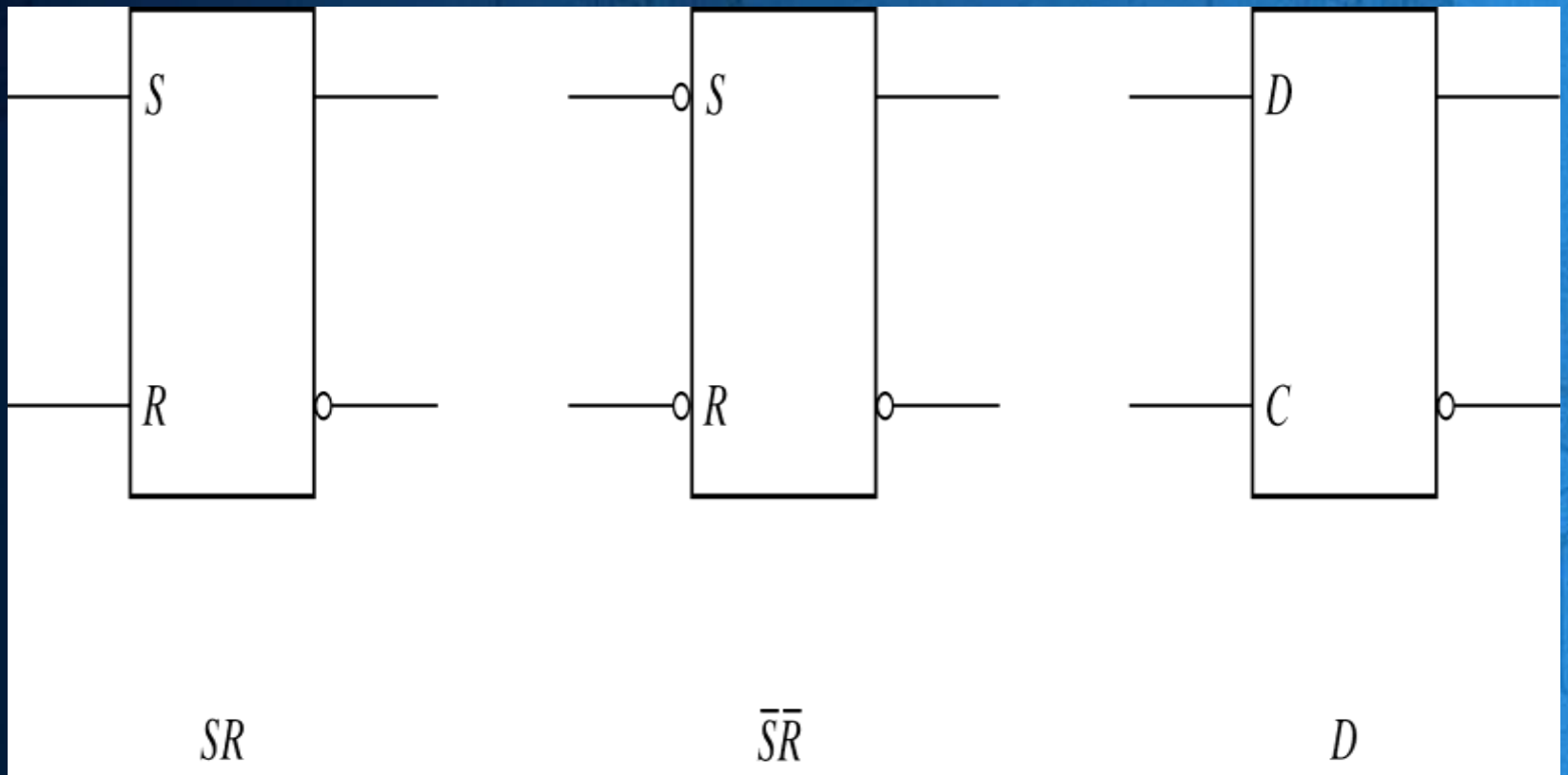


Fig. 5-7 Graphic Symbols for Latches

Questions

Quick Quiz (Poll 1)

- Why latches are called memory devices?

a) It has capability to store 8 bits of data
b) It has internal memory of 4 bit
c) It can store one bit of data
d) It can store infinite amount of data

Quick Quiz (Poll 2)

- The full form of SR is _____

a) System rated
b) Set reset
c) Set ready
d) Set Rated