AAB University
Faculty of Computer Sciences

Introduction to Digital Technologies and Circuits

Week 12:

Types of Sequential Logic Circuits

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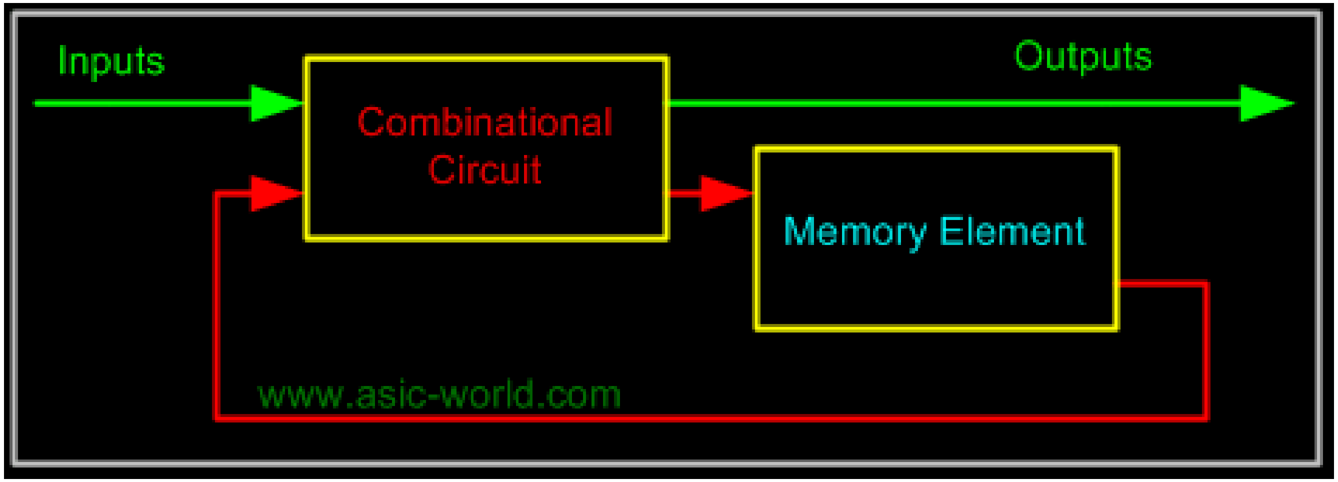
Digital Logic Circuits

- There are two types of Digital Logic Circuits:
  - Combinational Logic Circuits
  - Sequential Logic Circuits

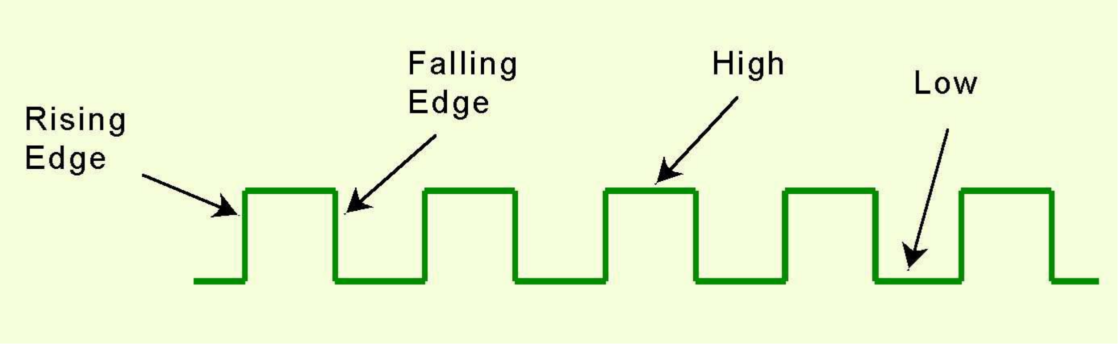


- Combinational logic output depends on the inputs levels, whereas sequential logic output depends on stored levels and also the input levels.

Sequential Logic Circuits

Types of Sequential Logic Circuits:

- A **synchronous** sequential circuit uses a clock to order events
  - a clock is a circuit that emits a series of electrical pulses
  - state changes in sequential circuits only occur when the clock ticks



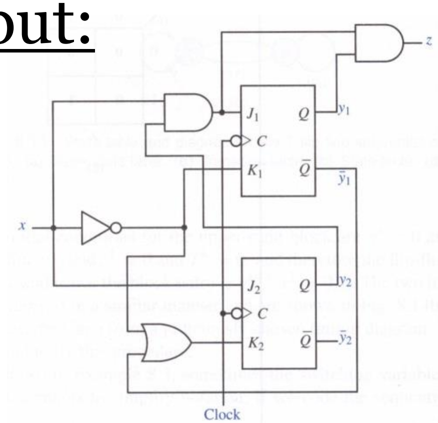
- **Asynchronous** sequential circuits become active the moment any input value changes

Synchronous Sequential Logic Circuit

I. Analysis of Synchronous Logic Circuit

Input:

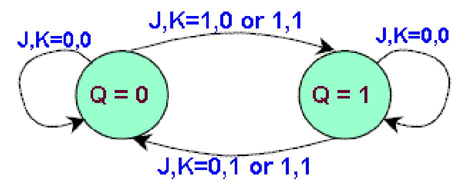
Ex:



Output:

Ex: In. and Out. sequence: OR State Diagram:

x=1011 »
z=1100

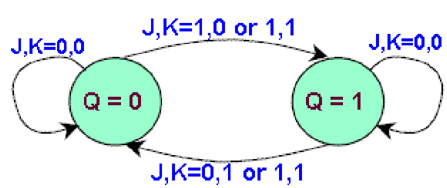


II. Design of Synchronous Logic Circuit

Input:

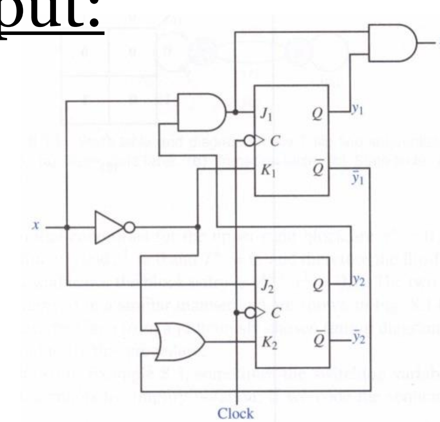
Ex: In. and Out. sequence: OR State Diagram:

x=1011 »
z=1100



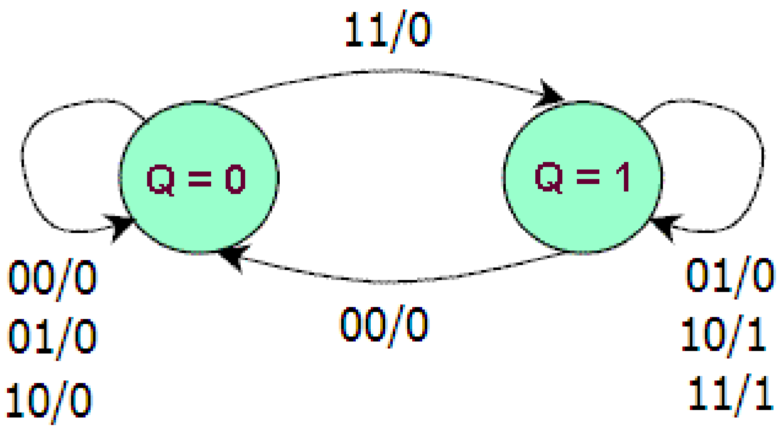
Output:

Ex:



Synchronous Sequential Circuit

- Example 1:
  - Design (and simulate) a sequential circuit with two inputs (X,Y) and one output Z, which is described with the following state diagram:

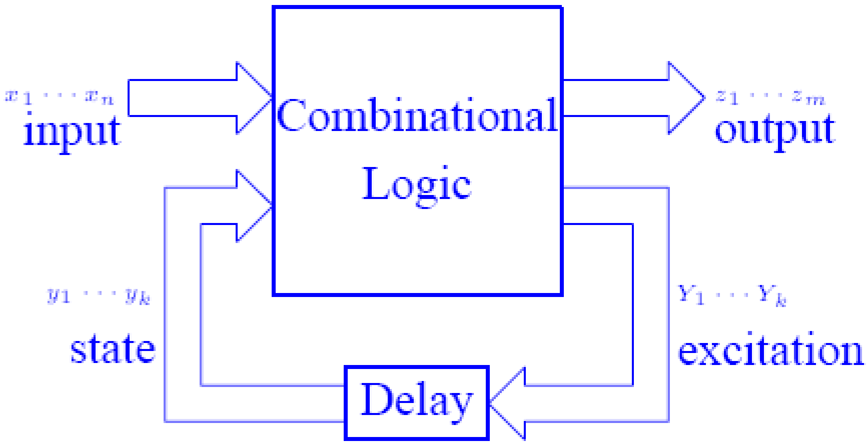


X	Y	Q	Q^+	Z	J	K
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

  - Use JK flip-flops!

Asynchronous Sequential Circuit

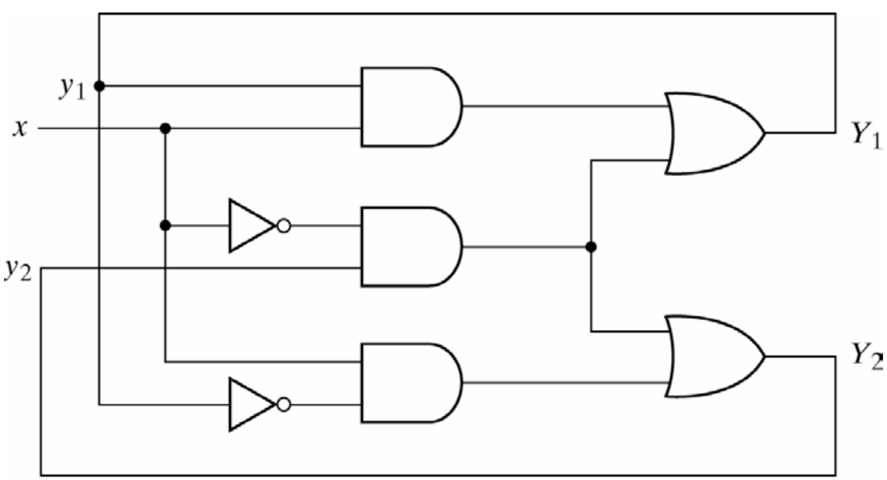
- An asynchronous sequential circuit is a sequential circuit whose behavior depends only on the order in which its input signals change and can be affected at any instant of time.



- $\mathbf{x} = (x_1, x_2, \ldots, x_n)$: n input variables
- $\mathbf{z} = (z_1, z_2, \ldots, z_m)$: m output variables
- $\mathbf{y} = (y_1, y_2, \ldots, y_k)$: k state variables (present state)
- $\mathbf{Y} = (Y_1, Y_2, \ldots, Y_k)$: k excitation variables (next state)

Asynchronous Sequential Circuit

- State transition occurs when there is an input change (no clock pulses).
- Memory (delay) elements are either latches (unclocked) or time-delay elements (instead of clocked Flip-Flops as in a synchronous sequential circuit).
- An asynchronous sequential circuit quite often resembles a combinational circuit with feedback.



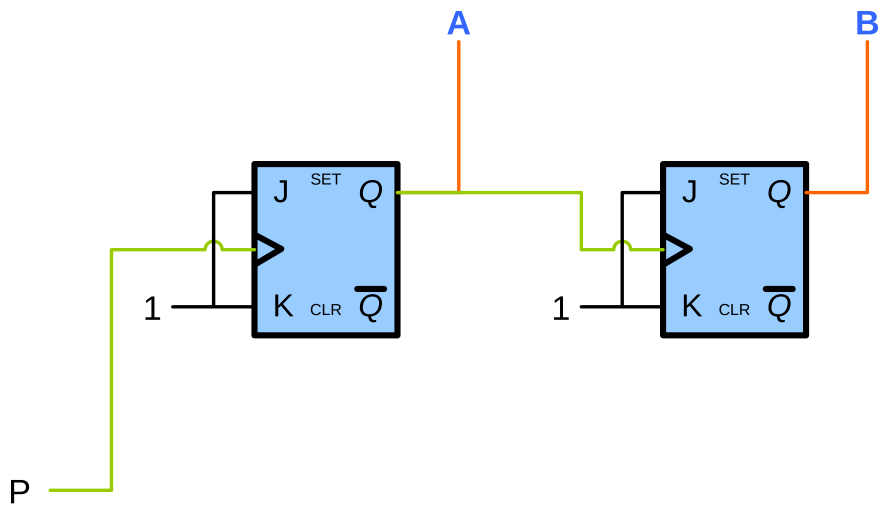
Asynchronous Sequential Circuit

- Faster and often cheaper than synchronous ones, but **more difficult to design**, verify, or test (due to possible timing problems involved in the feedback path).

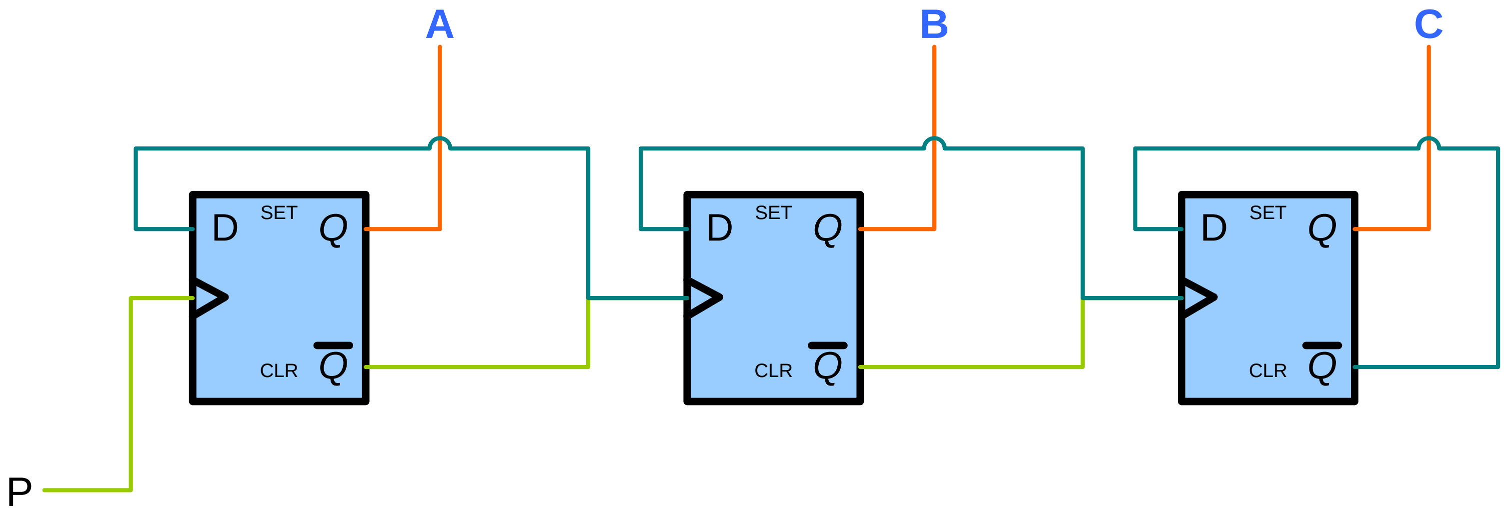
- To ensure proper operation, simultaneous changes of 2 or more input variables are usually prohibited.

- <u>Fundamental-mode operation</u>:
  - only one input variable can change at any time, and the time between 2 input changes must be longer than the time it takes the circuit to reach a stable state.

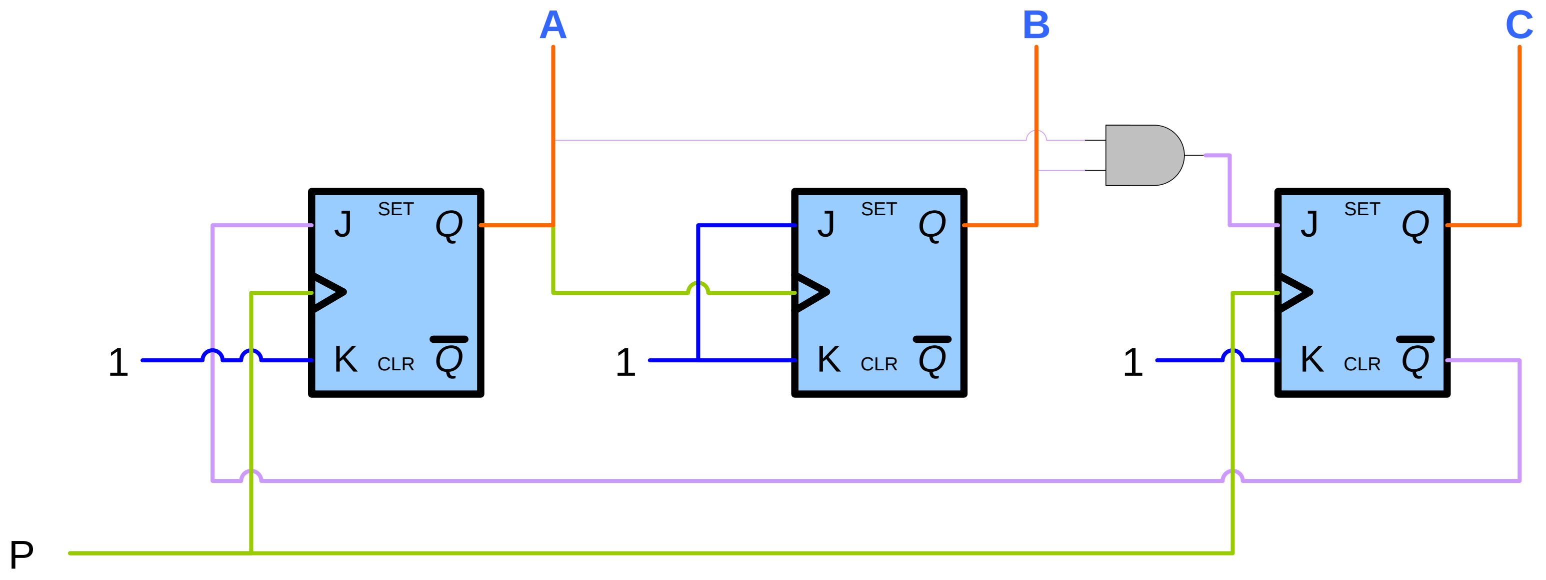
- Example 2:



- Example 3:


A
B
C
D
SET
Q
CLR
$\overline{Q}$
D
SET
Q
CLR
$\overline{Q}$
D
SET
Q
CLR
$\overline{Q}$
P

- Example 4:



- Questions?!

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