

Digital System Design

Module 4 - SEQUENTIAL LOGIC CIRCUITS

Dr. Deepthi Sasidharan

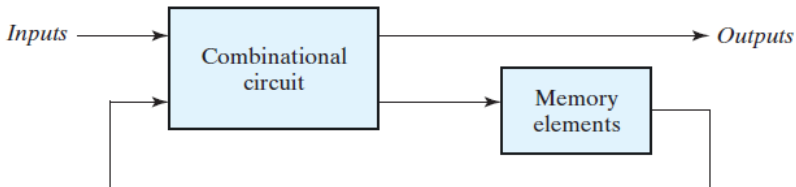
Assistant Professor, Department of Information Technology
GEC Barton Hill, Thiruvananthapuram

October 22, 2020

SEQUENTIAL CIRCUITS

- ▶ A combinational circuit — its output depends only and immediately on its inputs — they have no memory
- ▶ Sequential circuits, however, act as storage elements and have memory
- ▶ They can store, retain, and then retrieve information when needed at a later time
- ▶ The binary information stored in these elements at any given time defines the state of the sequential circuit at that time

SEQUENTIAL CIRCUITS



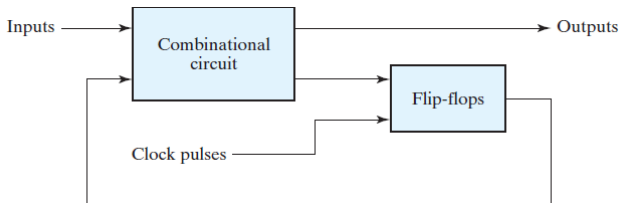
Block diagram of sequential circuit

A sequential circuit is specified by a time sequence of inputs, outputs, and internal states

SEQUENTIAL CIRCUITS

- ▶ There are two main types of sequential circuits, and their classification is a function of the timing of their signals.
 - ▶ A **synchronous sequential circuit** : it is a system whose behavior can be defined from the knowledge of its signals at discrete instants of time.
 - ▶ Synchronization is achieved by a timing device called a *clock generator*, which provides a clock signal having the form of a periodic train of *clock pulses*.
 - ▶ An **asynchronous Sequential Circuit**: The behavior depends upon the input signals at any instant of time and the order in which the inputs change.
 - ▶ The storage elements commonly used in asynchronous sequential circuits are *time-delay devices*

Synchronous Circuit



(a) Block diagram



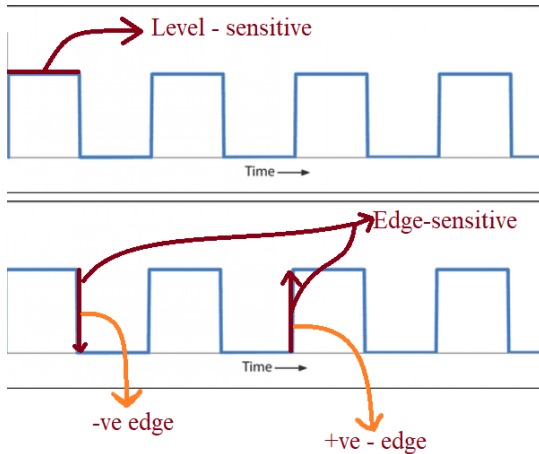
(b) Timing diagram of clock pulses

Synchronous clocked sequential circuit

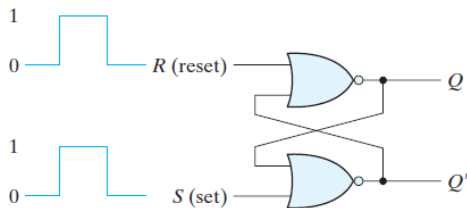
A flip-flop is a binary storage device capable of storing one bit of information

STORAGE ELEMENTS: LATCHES

- ▶ Storage elements that operate with signal levels (rather than signal transitions) are referred to as **latches** ; those controlled by a clock transition are **flip-flops**.
- ▶ Latches are said to be **level sensitive devices**; flip-flops are **edge-sensitive devices**.
- ▶ The two types of storage elements are related because latches are the basic circuits from which all flip-flops are constructed



SR Latch



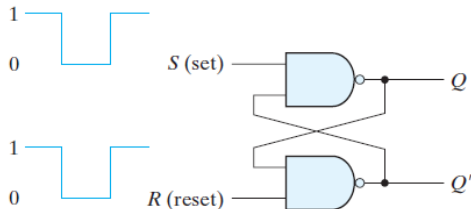
(a) Logic diagram

S	R	Q	Q'
1	0	1	0
0	0	1	0
0	1	0	1
0	0	0	1
1	1	0	0

(b) Function table

SR latch with NOR gates

SR Latch



(a) Logic diagram

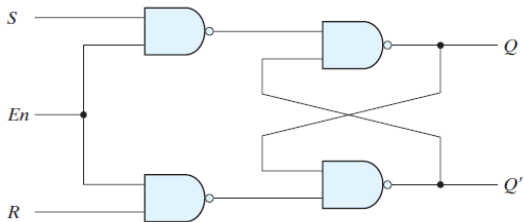
S	R	Q	Q'
1	0	0	1
1	1	0	1 (after $S = 1, R = 0$)
0	1	1	0
1	1	1	0 (after $S = 0, R = 1$)
0	0	1	1 (forbidden)

(b) Function table

SR latch with NAND gates

Because the NAND latch requires a 0 signal to change its state, it is sometimes referred to as an S'R' latch.

SR Latch



(a) Logic diagram

En	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

SR latch with control input