# Chapter 1

# Sequential Logic

## 1.1 Latches and Flip-flops

> Latches and flip-flops are fundamental building blocks in digital electronics used for storing binary information.

These bistable devices have two stable states, representing either a binary 0 or 1.

## 1.2 SR Latch

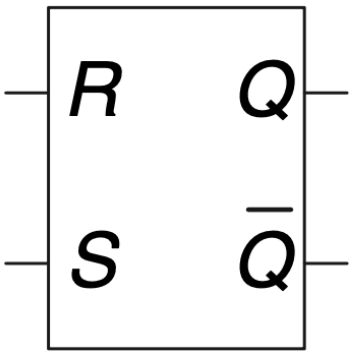
> The SR (Set-Reset) Latch is a simple storage device that holds one bit of data.

It features:

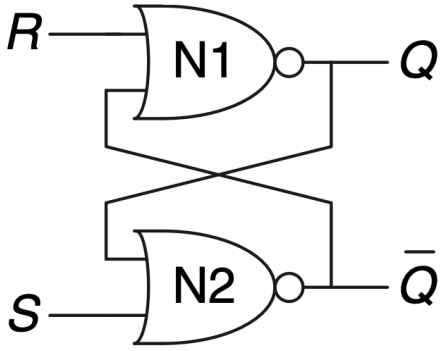
- Two inputs: S (Set) and R (Reset)
- Two outputs: Q and Q'
- Function: Set input sets output to 1, Reset input resets output to 0

**Note:-**

Avoid simultaneous activation of S and R to prevent undefined states




(a) SR Latch Symbol




(b) SR Latch Schematic

## 1.3 D Latch

> The D (Data or Delay) Latch captures input at specific times.

Key characteristics include:

- Single data input (D) and a clock input
- When clock is active: Output Q follows input D
- When clock is inactive: Output Q holds its last state

**Note:-**

D Latches are useful for data synchronization

## 1.4 D Flip-flop

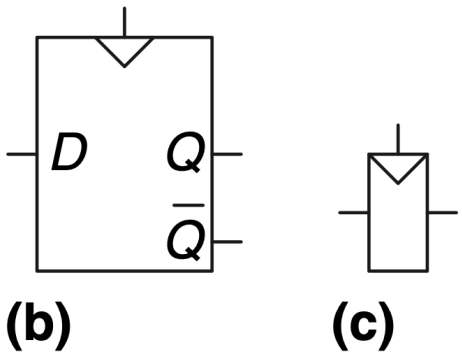
> The D Flip-flop is an edge-triggered device ideal for synchronous circuits.

Characteristics include:

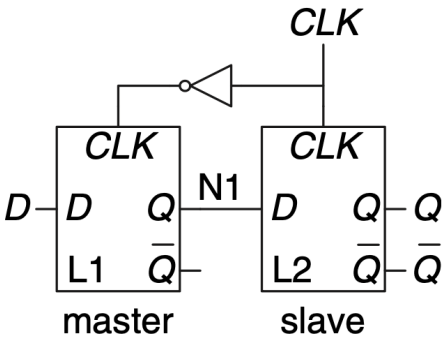
- Changes state only at clock signal edge (rising or falling)
- Captures D input value at clock edge
- Holds value until next clock edge

**Note:-**

D Flip-flops ensure precise timing in digital systems




(a) D Flip-flop Symbol




(b) D Flip-flop Schematic

## 1.5 Register

> A Register is composed of multiple flip-flops and is used to store and manipulate data.

Features include:

- Stores multiple bits of data
- Applications: data storage, transfer, and manipulation
- Configurable for operations like shifting, loading, and clearing

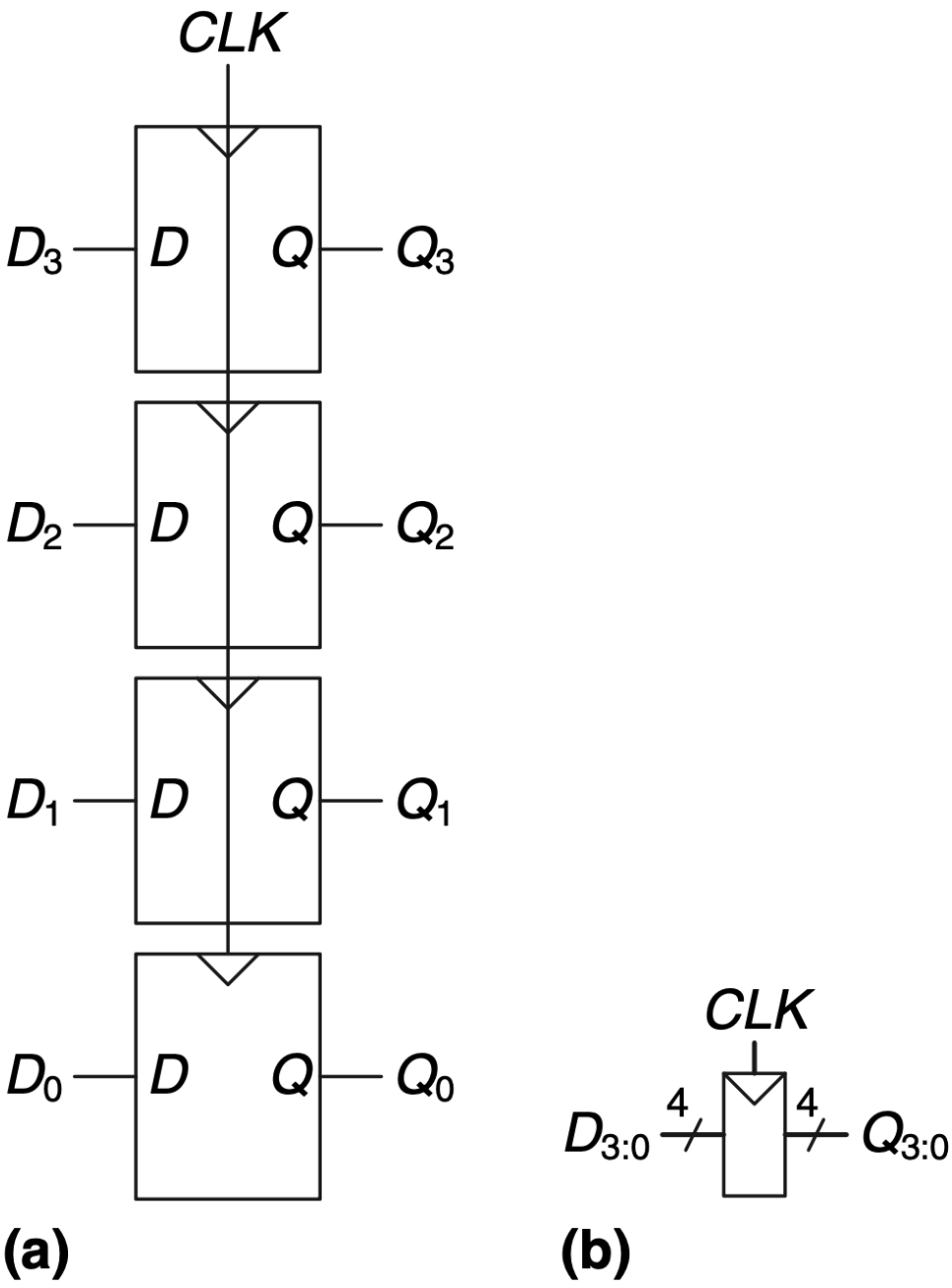



Figure 1.3: Register Schematic and Symbol

## 1.6 Enabled Flip-flop

> The Enabled Flip-flop adds control over data acceptance.

It includes:

- An enable input

- Enable active: Captures input data at clock edge
- Enable inactive: Retains current state regardless of input

## 1.7 Resettable Flip-flop

> A Resettable Flip-flop allows forced state changes.

It features:

- A reset input
- Can force flip-flop to a known state (typically 0)

**Note:-**

Resettable Flip-flops are useful for circuit initialization during power-up or specific conditions

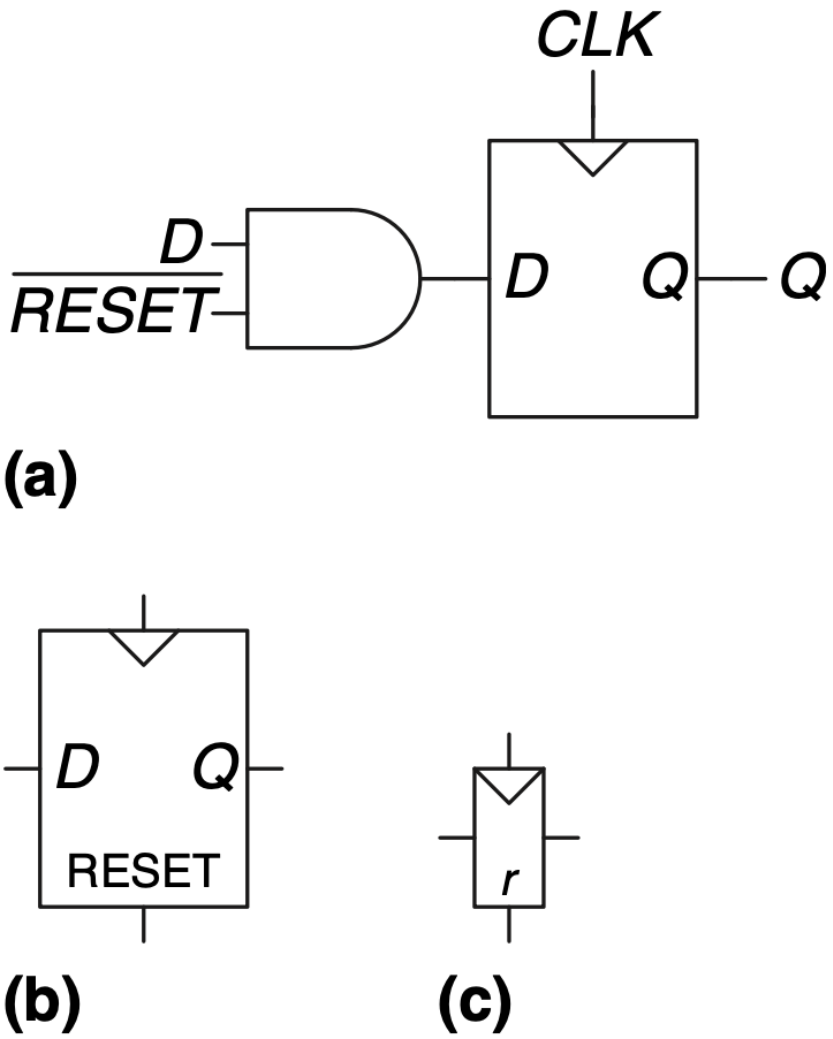



Figure 1.4: Resettable Flip-flop Schematic and Symbol

## 1.8 Counter

> Counters are sequential circuits for tracking events.

Characteristics include:

- Progresses through predetermined state sequence
- Implemented using flip-flops
- Can count up, down, or in specific patterns

**Note:-**

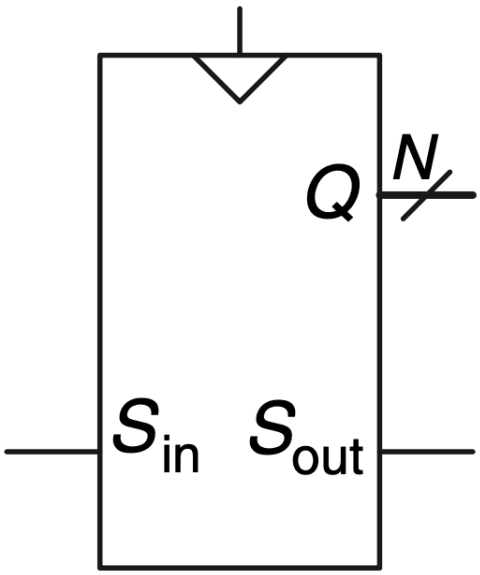
Counters are used for event occurrence counting

## 1.9 Shift Register

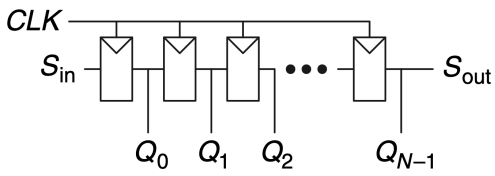
Shift Registers enable serial data manipulation.

Features include:

- Allows serial shifting of data in or out
- Composed of flip-flops in a chain
- Applications: data storage, transfer, and format conversion




(a) Shift Register Symbol




(b) Shift Register Schematic

### 1.9.1 Scan Chains

Scan Chains are crucial for digital circuit testing.

They are:

- Series of flip-flops connected in a chain
- Enables shifting of test data into and out of the circuit

**Note:-**

Scan Chains are used to test internal circuit states and ensure correct operation