Counters and Registers

1. Concept of Registers

A
is a small, fast storage unit in a digital system made up of a group of
connected together. It is used
to store multiple bits of binary data temporarily during processing
operations.
Since each flip-flop can store :
• A contains
and can store 4 bits of data

• An contains and can store 8 bits of data
Registers are very important because they
provide quick access to data during system operations.

Main Functions
of Registers

✔️

Registers hold data while it is being processed by the CPU.

✔️

They move data between different parts of a digital system.

✔️

Some registers support shifting and arithmetic operations.

Areas Where
Registers Are Used

• In the , such as the accumulator, instruction register, and data register

• In for
buffering data

• In to
handle serial and parallel data

2. Types of
Registers

Registers are classified based on how data
enters and leaves them.

(a) SISO –
Serial In Serial Out

In a , data enters and also leaves in the same sequence.
✔️ Input is serial

✔️
Output is serial
This type of register is mainly used in:
• Data transmission systems

• Delay circuits

(b) SIPO –
Serial In Parallel Out

In a , data enters serially but is available at the output in .
✔️ Input: one bit at a time

✔️
Output: all bits at once
This is useful when:
• Converting serial data to parallel data

• Receiving data from communication channels

(c) PISO –
Parallel In Serial Out

In a , multiple bits are loaded at the same time (parallel) and then shifted out one by one (serially).
✔️ Input: parallel

✔️
Output: serial
Used in:
• Data transmission

• Reducing number of wires required

(d) PIPO –
Parallel In Parallel Out

In a , data is loaded and taken out simultaneously in parallel form.
✔️ Input: parallel

✔️
Output: parallel
This type is best for:
• High-speed data storage

• Temporary data holding inside processors

3. Shift Registers

A is a register that shifts its stored data either when a clock pulse is applied.
Each clock pulse moves the data by one position.

Types of Shift Registers

- – shifts data towards left
- – shifts data towards right
- – can shift in both directions

Applications of Shift Registers

✔ Moving data between registers

✔ Performing arithmetic shifts (multiplication/division by 2)

✔ Temporary data storage

✔ Used in communication systems such as serial data transmission

4.
Applications of Registers

Registers play many roles in digital systems:

- Storing instructions in the CPU
- Holding data for processing
- Acting as buffers between system units
- Converting data between serial and parallel formats
- Speeding up computer operations

5. Counter
Basics

A
is a type of sequential circuit designed to applied to it.
With every clock pulse, the counter changes
its state in a predefined binary sequence.

Example: 3-bit
Binary Counter

000 → 001 → 010 → 011 → 100 → 101 → 110 → 111
After reaching 111, it resets to 000.

Common Uses of
Counters

✔️ Digital clocks

✔️
Timers

✔️
Event counting systems

✔️
Frequency measurement devices

6. Ripple vs
Synchronous Counters

Counters can be classified based on how clock
pulses are applied.

Ripple
(Asynchronous) Counter

• Clock pulse is applied only to the first
flip-flop

• The output of one flip-flop triggers the next

• Each flip-flop changes state after the previous one
⚠ This causes delay known as
✔️ Simple design

❌ Slower operation

Synchronous
Counter

• All flip-flops receive the clock signal at the same time

• All states change simultaneously
✔️ Fast

✔️
Accurate

❌ More complex circuit design

Comparison
Table

Feature

Ripple
Counter

Synchronous
Counter

Speed

Slow

Fast

Delay

High

Very
low

Design

Simple

Complex

Usage

Small systems

Modern systems

7. Up/Down Counters

Up Counter

Counts forward in increasing order:
0 → 1 → 2 → 3 → 4 ...

Down Counter

Counts backward:
4 → 3 → 2 → 1 → 0 ...

Up/Down
Counter

Has a control input that determines counting direction.
✔️ If control = 1 → counts up

✔️
If control = 0 → counts down

Applications

- Elevator control systems
- Digital scoreboards
- Timers and clocks

8. Mod-N
Counters

A is a counter that counts from and then resets back to zero.

Example:
Mod-10 Counter

Counts:
0 → 1 → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → reset

Where Mod-N
Counters Are Used

✔️ Digital clocks (seconds, minutes)

✔️
Calculators

✔️
Frequency dividers

✔️
Electronic displays

9. Mod-10
Counter Design (Simple Explanation)

To design a :

Step 1:
Determine number of flip-flops

Since:
$2^3 = 8$ (not enough)

$2^4 = 16$ (sufficient)
👉 Use

Step 2: Normal
Counting

The counter counts naturally:
0000 (0) → 0001 (1) → ... → 1001 (9)

Step 3: Reset
Condition

When the counter reaches:
1010 (10)
A logic gate detects this and sends a to bring it back to:
0000 (0)

This ensures the counter only counts from 0 to 9.

CONCLUSION

Registers and counters are fundamental building blocks of digital systems.

- Registers store and transfer binary data
- Shift registers move data efficiently

- Counters track events and time

- Mod-N counters control counting limits

Together, they form the backbone of computers, digital clocks, and control systems.