Module 9 : Register and Counter

Learning Objectives:

1. Understand the concept of parallel and serial binary operations
2. Understand a combination and conversion of parallel and binary operations

- Theory

Theory

A. Binary Operation

In electrical components, data is represented as a **stream of bits**. These bits are processed in the components, creating processed bits of data. This process is called a **binary operation**. Binary operations are further classified into:

1. Parallel Operation

The parallel operation works **instantly without a timer**. **Input bits are processed together at the same time**, producing output bits in a short amount of time. This operation is very effective for quick outputs but is expensive for larger bits.

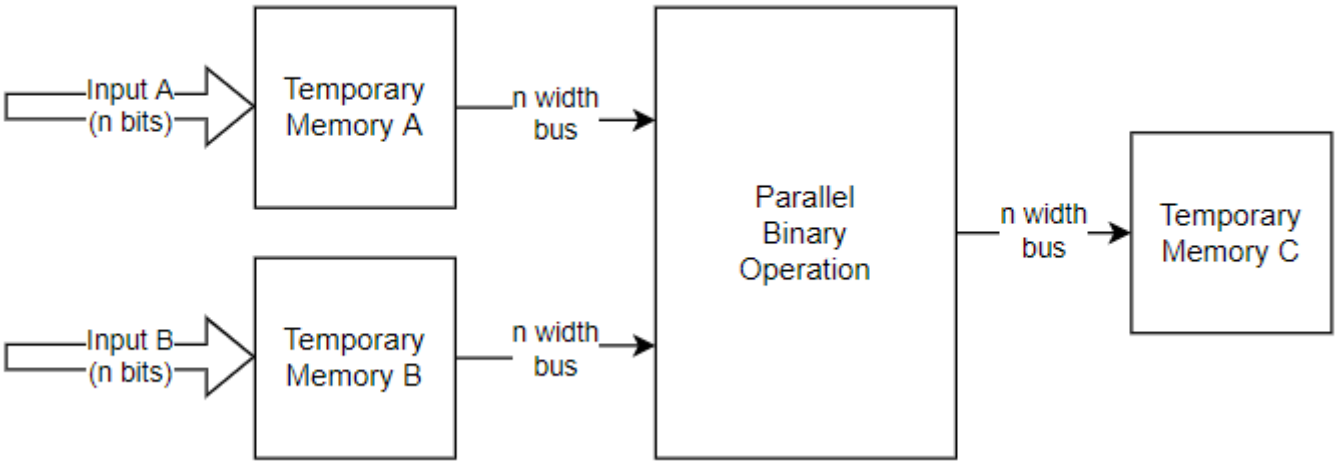

Figure 1-1: Parallel Operation Block Diagram In this design type, optimized design is key to produce efficient and cost effective designs.

2. Serial Operation

In serial operation, **input bits** are processed **one by one**, creating output **sequentially**. A **timer** ensures that the input produces the correct output and shifts the data in the correct order. Memory is also needed to store the input and output bits, often achieved using a **shift register**.

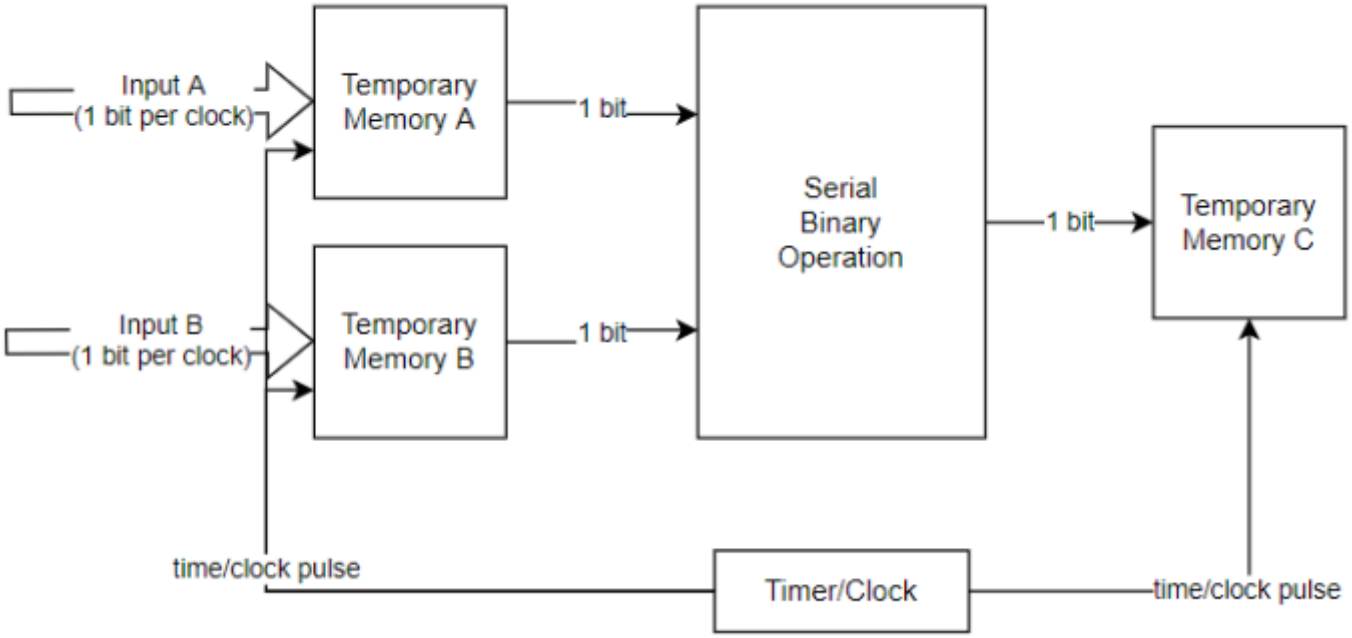

Figure 1-2: Serial Operation Block Diagram The block doesn't need a timer pulse since it works instantly for every input change. The output is also saved at every pulse, sequentially.

3. Combination

A combination of parallel and serial operations can be used to balance speed and cost. This hybrid operation requires a timer to mark the beginning and end of the serial part before and after the parallel part.

B. Register

To save data in a digital circuit, a **register** is used. A register saves data using signal bits with flip-flops and states. Registers can be designed using a combination of serial and parallel operations, such as **Serial Input Parallel Output (SIPO)** and **Parallel Input Serial Output (PISO)** registers.

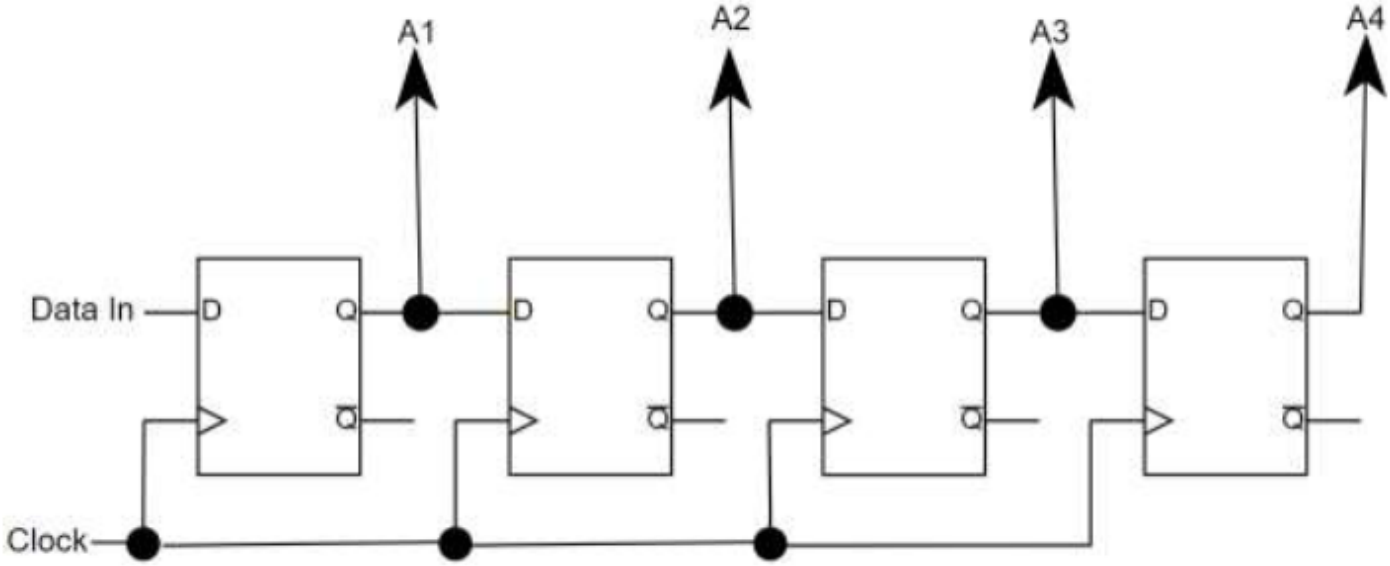

Figure 2-1: SIPO Register

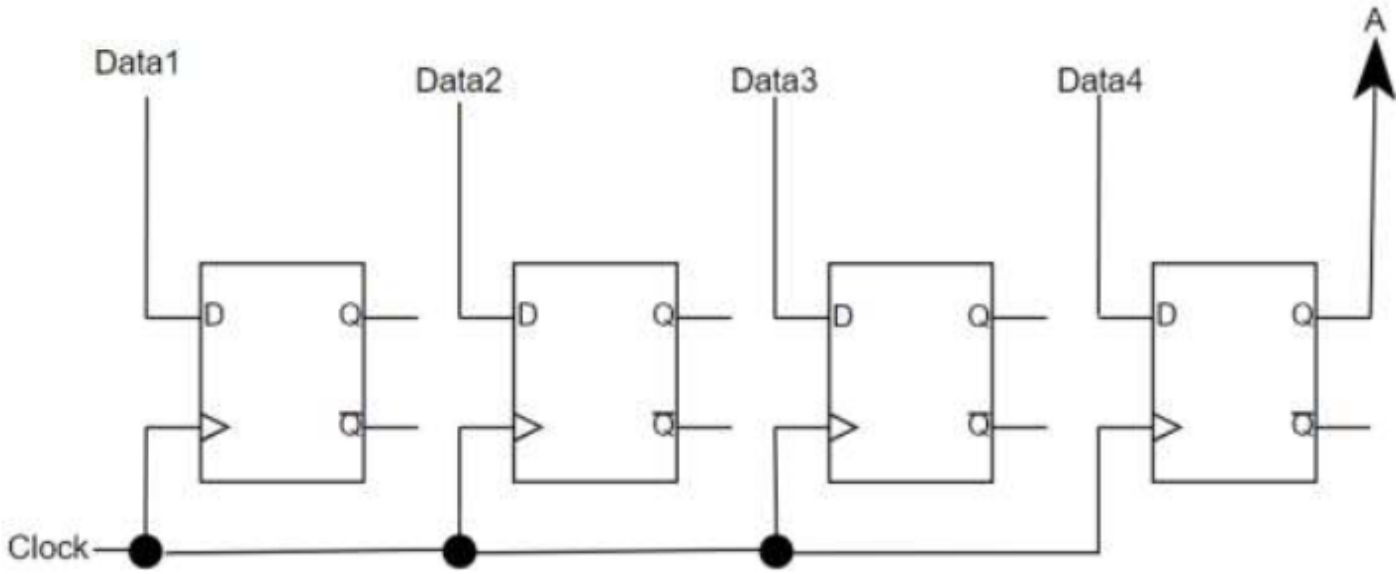

Figure 2-2: PISO Register

The main component of a register is the **flip flop, a clock (or enabler), input, and output**. The main difference between parallel and serial is how the signal is handled. If **more than one** signal is handled simultaneously, then it is called **parallel**. If only **one signal is handled one by one**, then it is called **serial**.

C. Counter

A **counter** is used to control sequences and execution steps in a logical circuit by counting bits. Counters consist of flip-flops that switch states in sequence. There are two types of counters:

- **Synchronous Counter**: All flip-flops are connected and controlled at the same time by the same external clock.

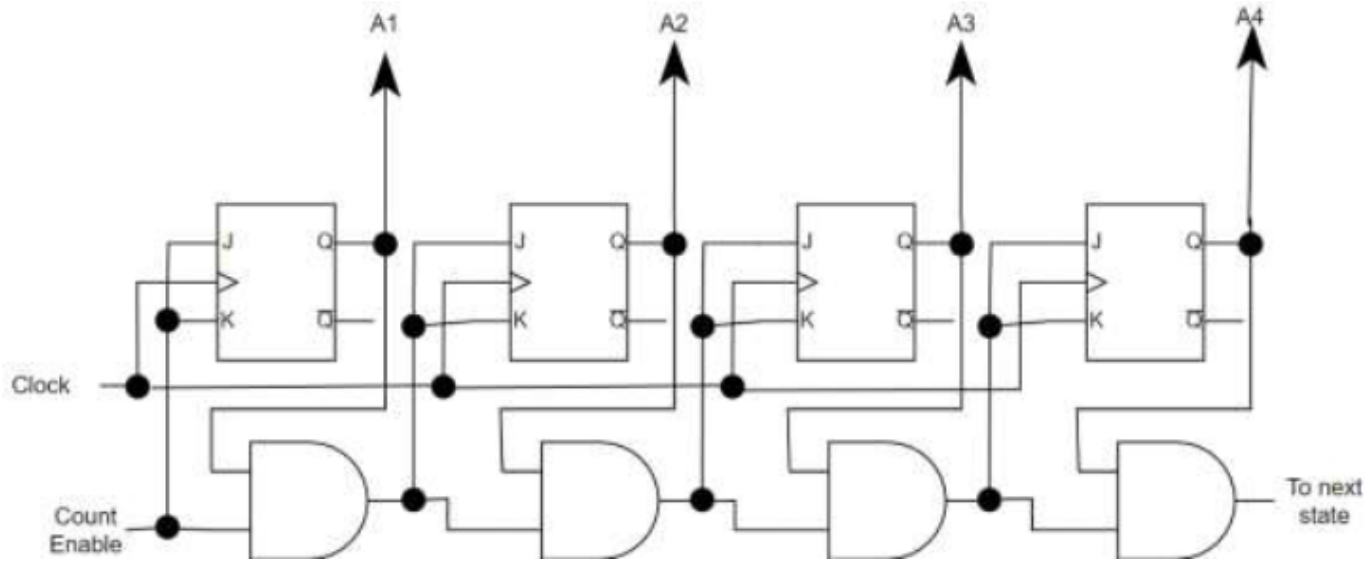

Figure 3-1: 4-bit Synchronous Counter

- **Asynchronous Counter**: Flip-flops are controlled by the output of the previous flip-flop, except for the first one, which is controlled by an external clock.

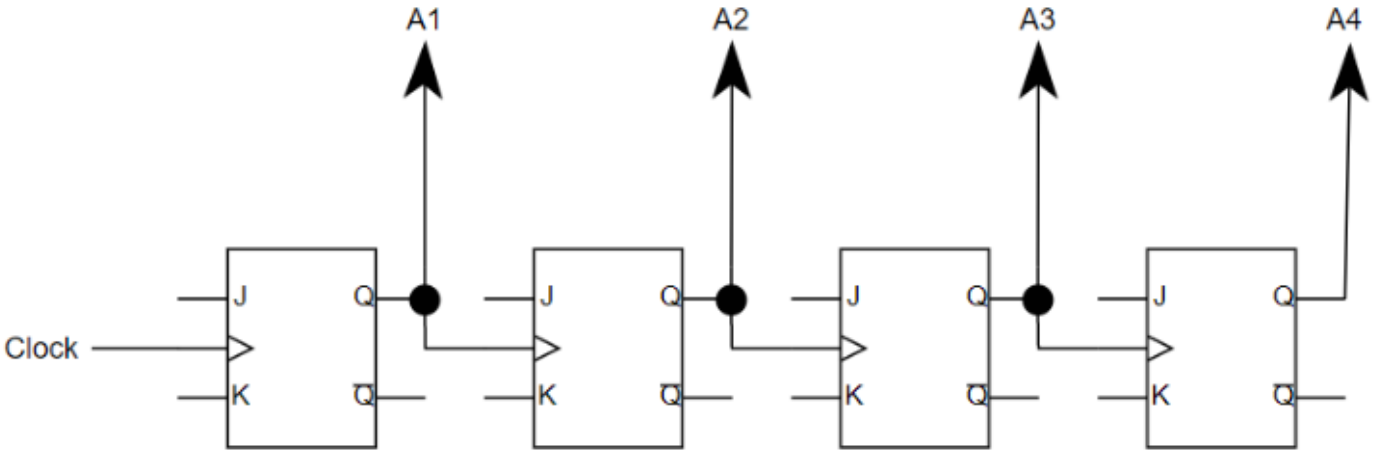

Figure 3-2: 4-bit Asynchronous Counter

Counters can count up, count down, or both, and may use different coding schemes, such as **n-bit binary counters** or **n-bit BCD counters**. A counter that counts from 0 to 9 (0000 to 1001) is called a **decade counter**.

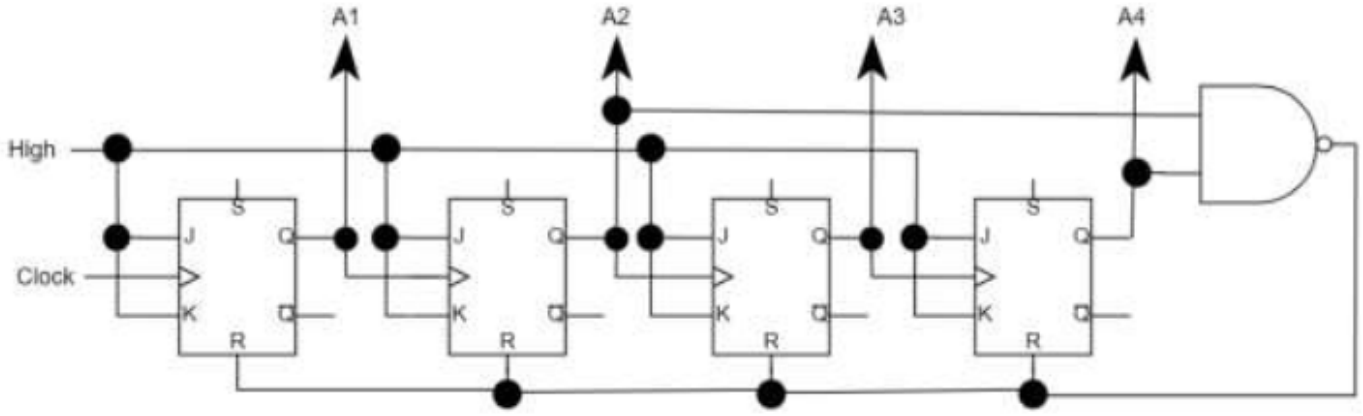

Figure 4-1: 4-bit Decade Counter