COMPUTER ARCHITECTURE

2nd Year Computer science

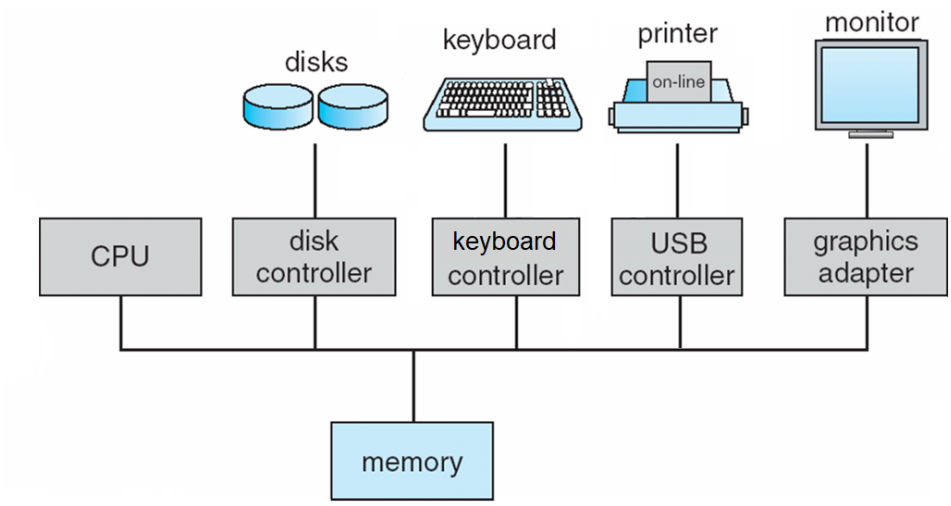
Chapiter 2:

Main components of a computer

Abdelhafid Boussouf University Center
2024-2025

Computer components

Computer components



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Computer components

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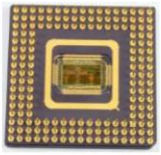
Computer components

There are **three** main components of a **Computer System**.

- ***Central Processing Unit (CPU):*** Also simply called as the microprocessor acts as the brain coordinating all activities within a computer.
- ***Memory:*** The program instructions and data are primarily stored.
- ***Input/output (I/O) Devices:*** Allow the computer to input information for processing and then output the results. I/O Devices are also known as computer peripherals.



- The integrated Circuit (IC) chip containing the CPU is called the ***microprocessor***.
- A microcomputer is a relatively smaller computer with a central processing unit (***CPU***) as a ***microprocessor***. A microcomputer is typically used as a personal computer (PC) which is smaller than a mainframe computer.

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Computer components

The CPU is connected to memory and I/O devices through a strip of wires called a ***bus***. The bus inside a computer carries information from place to place. There are three types of busses:

1. ***Address Bus:*** The address bus is used to identify the memory location or I/O device the processor intends to communicate with. The width of the Address Bus rages from **20 bits (8086)** to **36 bits for (Pentium II).**
2. ***Data Bus:*** Data bus is used by the CPU to get data from / to send data to the memory or the I/O devices. The width of a microprocessor is used to classify the microprocessor. The size of data bus of Intel microprocessors vary between **8-bit (8085)** to **64-bit (Pentium).**
3. ***Control Bus:*** How can we tell if the address on the bus is memory address or an I/O device address? This is where the control bus comes in. Each time the processor outputs an address it also activates one of the four control bus signals: **Memory Read**, **Memory Write**, **I/O Read** and **I/O Write**.

The ***address and control bus*** contains output lines only, therefore it is ***unidirectional***, but the ***data bus*** is ***bidirectional***.

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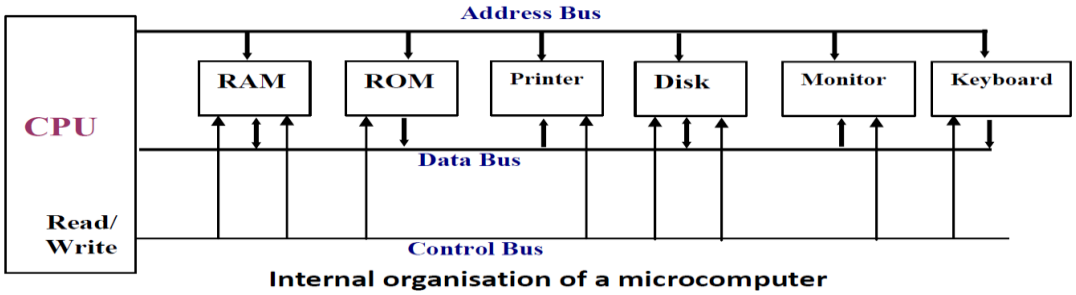
Computer components

There two types of memory used in microcomputers:

- ***RAM* (Random Access Memory/ Read-Write memory)** is used by the computer for the temporary storage of the programs that is running. Data is lost when the computer is turned off. So known as ***volatile*** memory.
- ***ROM* (Read Only Memory)** the information in ROM is permanent and not lost when the power is turned off. Therefore, it is called ***nonvolatile*** memory.

Note that RAM is sometimes referred as ***primary storage***, where magnetic /optical disks are called ***secondary storage***.



Internal organisation of a microcomputer

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Computer components

Inside the CPU:

A program stored in the memory provides instructions to the CPU to perform a specific action. This action can be a simple addition. It is function of the CPU to ***fetch*** the program instructions from the memory and ***execute*** them.

- The CPU contains a number of ***registers*** to store information inside the CPU temporarily. Registers inside the CPU can be 8-bit, 16-bit, 32-bit or even 64-bit depending on the CPU.
- The CPU also contains ***Arithmetic and Logic Unit (ALU).*** The ALU performs arithmetic (add, subtract, multiply, divide) and logic (AND, OR, NOT) functions.
- The CPU contains a program counter also known as the ***Instruction Pointer*** to point the address of the next instruction to be executed.
- ***Instruction Decoder*** is a kind of dictionary which is used to interpret the meaning of the instruction fetched into the CPU. Appropriate control signals are generated according to the meaning of the instruction.

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Computer components

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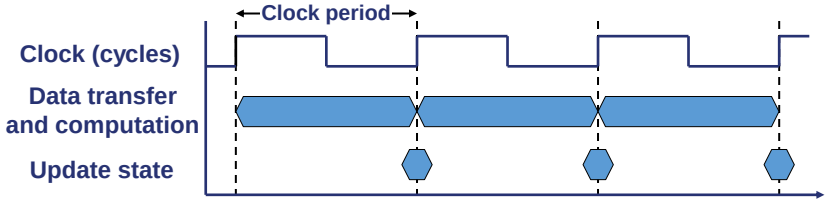
CPU Clocking



- Operation of digital hardware governed by a constant-rate clock
- Clock period: duration of a clock cycle
  - e.g., 250 ps = 0.25 ns = 250×10^{-12} s
- Clock frequency (rate): cycles per second
  - e.g., 4.0 GHz = 4000 MHz = 4.0×10^{9} Hz

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CPU Time

$$\text{CPU Time} = \frac{\text{Instructions}}{\text{Program}} \times \frac{\text{Clock cycles}}{\text{Instruction}} \times \frac{\text{Seconds}}{\text{Clock cycle}}$$

- Performance depends on
  - Algorithm: affects IC, possibly CPI
  - Programming language: affects IC, CPI
  - Compiler: affects IC, CPI
  - Instruction set architecture: affects IC, CPI, T_c

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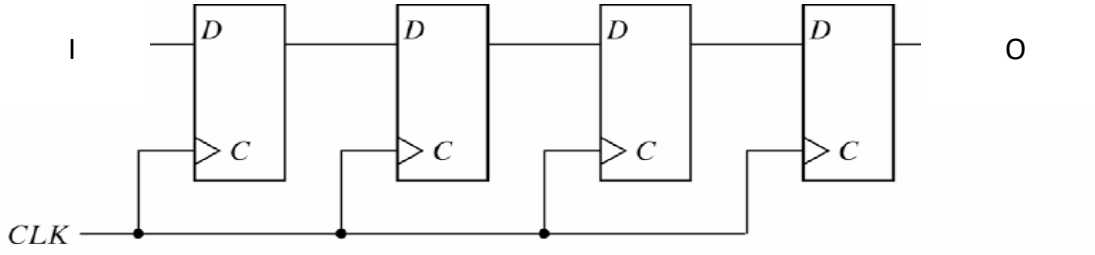
Registers & Counter

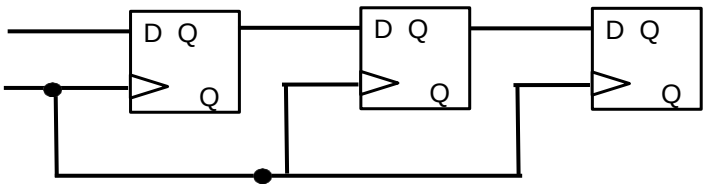
- Circuits that include flip-flops are usually classified by the function they perform
  - Registers
  - Counters
- Register is a group of flip-flops.
  - Each flip-flop is capable of storing one bit of information.
  - An n-bit register consists of a group of n flip-flops.
  - Register is a group of binary cells suitable for holding binary information.
- A counter is essentially a register that goes through a predetermined sequence of states.

4-Bit Register



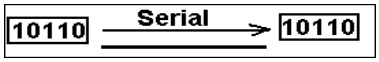
3-Bit Register

- Shift registers are comprised of D Flip-Flops that share a common clock input.

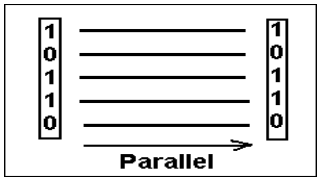


Parallel versus Serial

- Serial communications: provides a binary number as a sequence of binary digits, one after another, through one data line.

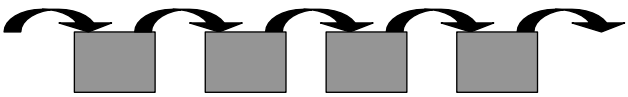


- Parallel communications: provides a binary number as binary digits through multiple data lines at the same time.

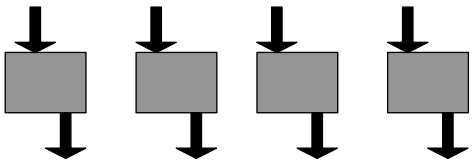


Shift Registers

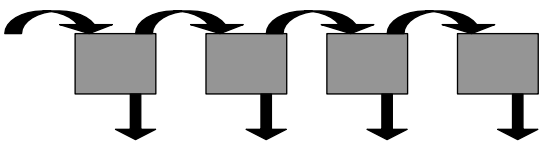
- Shift Registers are devices that store and move data bits in serial (to the left or the right),



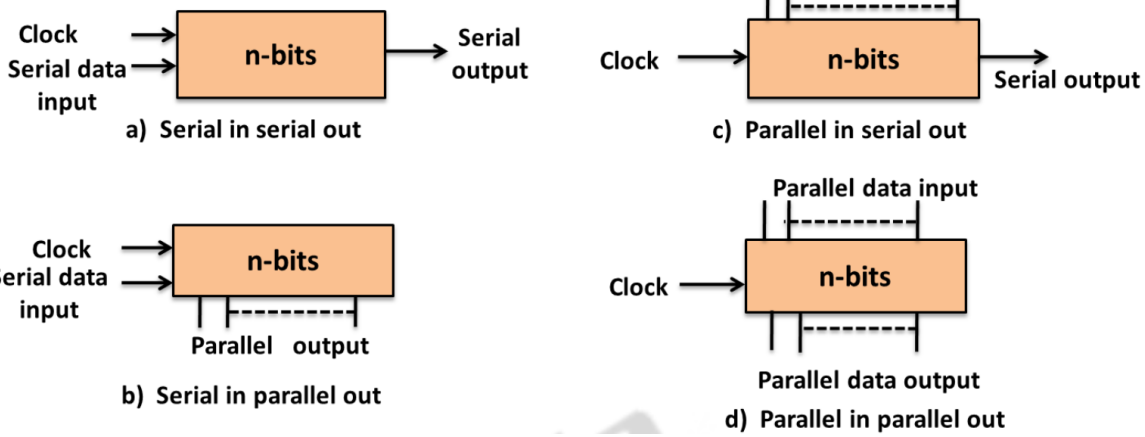
- ..or in parallel,



- ..or a combination of serial and parallel.



Types of registers



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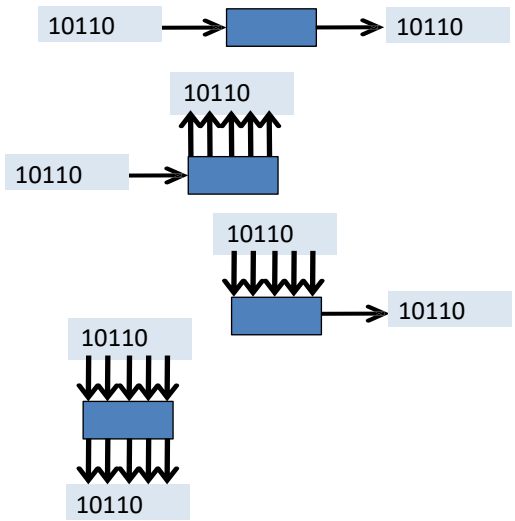
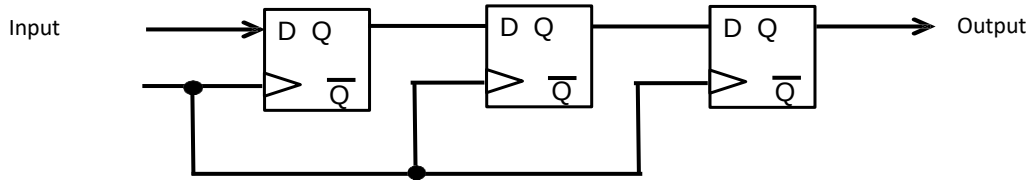
Combinations of Data Transfer Methods

- SISO: Serial In, Serial Out
- SIPO: Serial In, Parallel Out
- PISO: Parallel In, Serial Out
- PIPO: Parallel In, Parallel Out



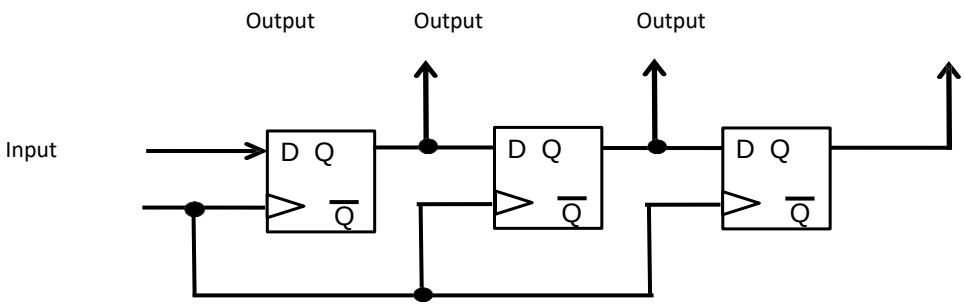
SISO Register

- **Serial In Serial Out** shift register has a single input and a single output



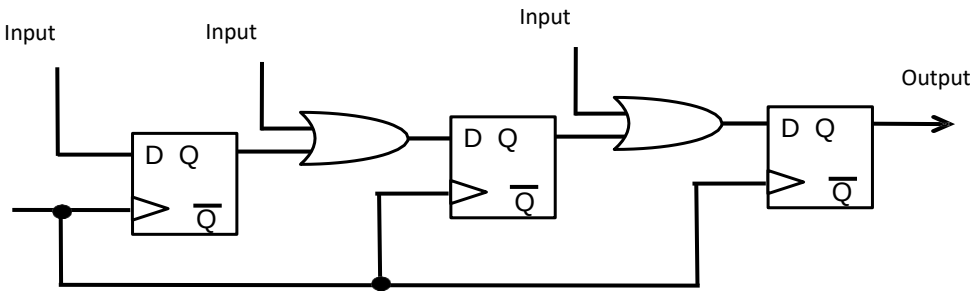
SIPO Register

- Serial In Parallel Out shift register has a single input and access to all outputs



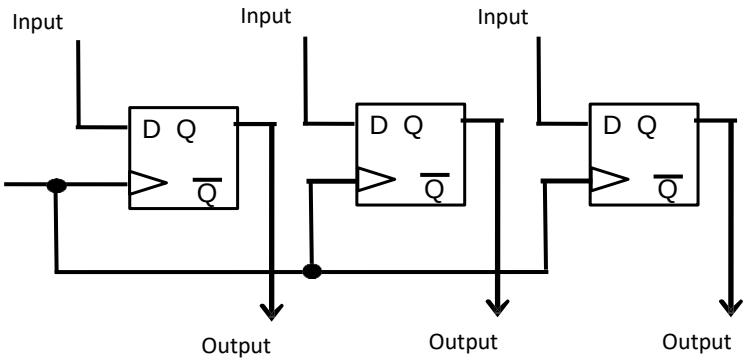
PISO Register

- a **Parallel In Serial Out** shift register requires additional gates, and the parallel input must revert to logic low.



PIPO Register

- **Parallel In Parallel Out** register has the simplest configuration. It represents a memory device.



Applications of shift registers

Shift Registers are an important Flip-Flop configuration with a wide range of applications, including:

- Computer and Data Communications
- Serial and Parallel Communications
- Multi-bit number storage
- Sequencing
- Basic arithmetic such as scaling (a serial shift to the left or right will change the value of a binary number a power of 2)
- Logical operations

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