

# Calculator

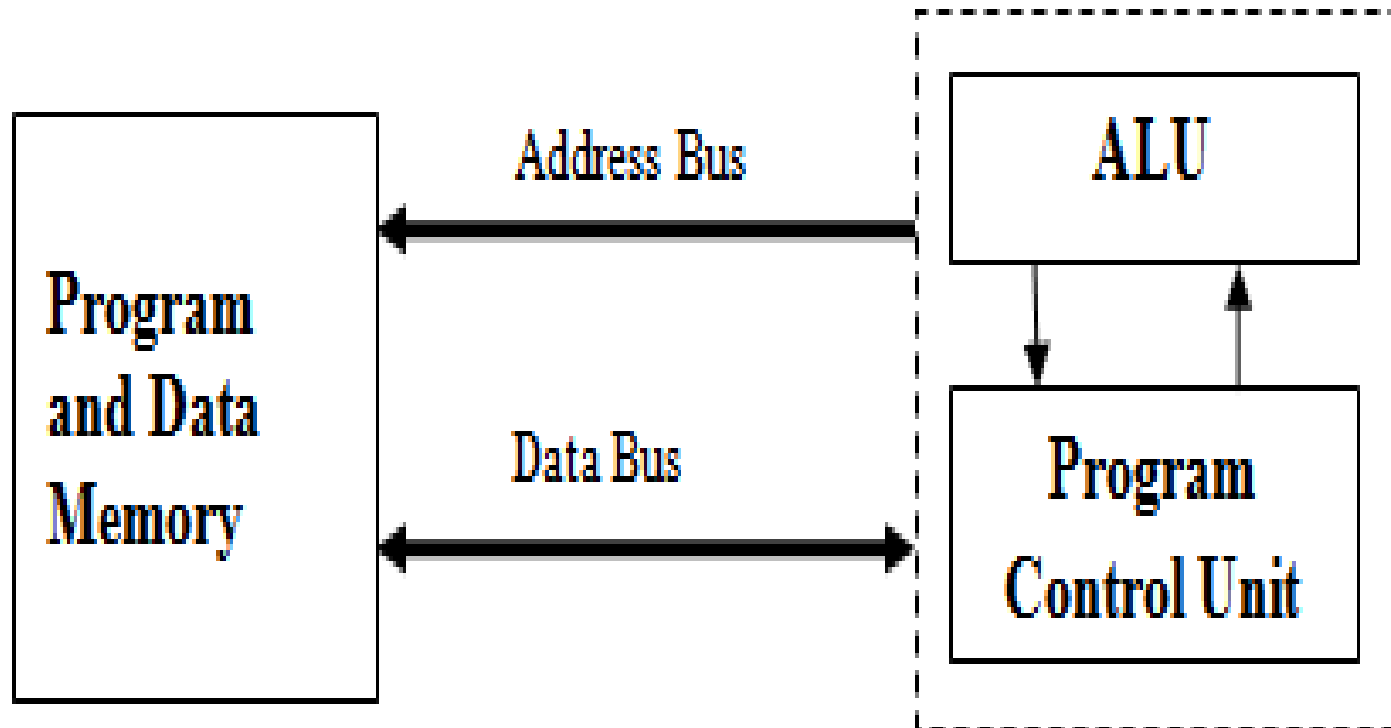
- **Data processing device** that carries out logic and arithmetic operations.
- Accepts data from a small keyboard, performs the **arithmetic and logical calculation** and show the result on LCD or LED.
- **Programs are stored in ROM**, data stored in RAM.

## Features

- Interface easily with keyboards and displays.
- Handle decimal digits as units.
- Execute the standard program stored in ROM
- Mathematical functions
- Low cost, small size and **low power consumption.**

# Von-Neumann Architecture

- Known as “**stored program concept**” and was developed by John Von Neumann.
- Computer could **get instruction by reading them from memory** and a program could be set or altered by setting the values of a portion of memory.



Von-Neumann Architecture

- Uses a single memory to hold both the instruction and data.
- Such machines are also known as **stored program computer**.
- ALU is capable of performing arithmetic and logical operations on binary data.

- The memory of the Neumann's machine consists of **1000 storage location called words**, each capable of storing 40 bits.
- Each number is represented by **sign bit and 39-bit value**.
- Control unit provides the **timing and control signals** to all the operations.

- The storage location of the control unit and ALU are called register.

**1. Memory Address Register (MAR):** located in the CPU, connected to the address lines.

Specifies the address in memory.

**2. Memory Buffer Register (MBR):** Located in the CPU, connected to the data lines. Acts as an interface between the CPU and memory.

- **Instruction Register (IR ):** When the instruction is fetched from the memory, it is loaded in the instruction register.
- **Program Control (PC):** Contains the **address of next byte to be fetched from the memory**. The main purpose is to sequence the execution of the program.



- The contents of the program counter are copied to the **memory address register** before an instruction is fetched from memory.
- When the instruction is fetched, the control unit updates the program counter to **point to the next instruction which is to be fetched.**

- The Accumulator (AC) and the Multiplier-Quotient (MQ) are employed to temporarily hold the operands and result of ALU operations.
- E.g., the result of multiplying the two 40-bit numbers is 80-bit number, the most significant 40 bit are stored in AC and the least significant in MQ.

# Harvard Architecture



Harvard Architecture

- Consists of separate memory for program and data.
- Each memory has its own address and data buses.
- Both the instruction and data can be fetched from memory concurrently.

- Consists of separate data and address buses for program and data memory.
- Hence it requires separate block of RAM chip.
- The data memory address bus carries the memory address of data whereas program memory address bus carries the memory address of the instruction.

- Similarly, **program memory data bus** carries the instruction and data memory data bus carries the data required to perform the operations.

# Microprocessor

- A  $\mu$ P is a programmable, clock driven electronic device, designed with registers, flip-flops & timing elements that reads binary instruction from a storage device called memory, accept binary data as input and process data according to those instruction and provide the results as output.

- It has a **set of instructions**, designed to manipulate data and communicate.
- It **can be programmed** to perform specific task by selecting necessary instruction from its set.
- It **reads one instruction at a time**, matches it with instruction set and performs the data manipulation as indicated by the instruction.



- Thus  $\mu$ P can fetch instruction from memory, decode and execute them, perform arithmetic and logical operations, accept data from input and send results to the output device.
- The CPU of computer consists of an ALU, CU and memory.

- If all these components can be organized on a **single silicon chip by means of LSI, VLSI** technology, then such structure is called  $\mu$ P.
- So the microprocessor is CPU in a single chip.