

Basic Concepts of Microprocessors

- Differences between:
 - Microcomputer – a computer with a microprocessor as its CPU. Includes memory, I/O etc.
 - Microprocessor – silicon chip which includes ALU, register circuits & control circuits
 - Microcontroller – silicon chip which includes microprocessor, memory & I/O in a single package.

What is a Microprocessor?

- The word comes from the combination micro and processor.
 - Processor means a device that processes whatever. In this context processor means a device that processes numbers, specifically binary numbers, 0's and 1's.
 - To process means to manipulate. It is a general term that describes all manipulation. Again in this content, it means to perform certain operations on the numbers that depend on the microprocessor's design.

What about micro?

- Micro is a new addition.
 - In the late 1960's, processors were built using discrete elements.
 - These devices performed the required operation, but were too large and too slow.
 - In the early 1970's the microchip was invented. All of the components that made up the processor were now placed on a single piece of silicon. The size became several thousand times smaller and the speed became several hundred times faster. The “Micro”Processor was born.

Was there ever a “mini”-processor?

- No.
 - It went directly from discrete elements to a single chip. However, comparing today’s microprocessors to the ones built in the early 1970’s you find an extreme increase in the amount of integration.
- So, What is a microprocessor?

Definition of the Microprocessor

The microprocessor is a programmable device that takes in numbers, performs on them arithmetic or logical operations according to the program stored in memory and then produces other numbers as a result.

Definition (Contd.)

- Lets expand each of the underlined words:
 - **Programmable device**: The microprocessor can perform different sets of operations on the data it receives depending on the sequence of instructions supplied in the given program.
By changing the program, the microprocessor manipulates the data in different ways.
 - **Instructions**: Each microprocessor is designed to execute a specific group of operations. This group of operations is called an instruction set. This instruction set defines what the microprocessor can and cannot do.

Definition (Contd.)

- **Takes in:** The data that the microprocessor manipulates must come from somewhere.
 - It comes from what is called “input devices”.
 - These are devices that bring data into the system from the outside world.
 - These represent devices such as a keyboard, a mouse, switches, and the like.

Definition (Contd.)

- **Numbers:** The microprocessor has a very narrow view on life. It only understands binary numbers.

A binary digit is called a bit (which comes from binary digit).

The microprocessor recognizes and processes a group of bits together. This group of bits is called a “word”.

The number of bits in a Microprocessor’s word, is a measure of its “abilities”.

Definition (Contd.)

– Words, Bytes, etc.

- The earliest microprocessor (the Intel 8088 and Motorola's 6800) recognized 8-bit words.
 - They processed information 8-bits at a time. That's why they are called "8-bit processors". They can handle large numbers, but in order to process these numbers, they broke them into 8-bit pieces and processed each group of 8-bits separately.
- Later microprocessors (8086 and 68000) were designed with 16-bit words.
 - A group of 8-bits were referred to as a "half-word" or "byte".
 - A group of 4 bits is called a "nibble".
 - Also, 32 bit groups were given the name "long word".
- Today, all processors manipulate at least 32 bits at a time and there exists microprocessors that can process 64, 80, 128 bits

Definition (Contd.)

– Arithmetic and Logic Operations:

- Every microprocessor has arithmetic operations such as add and subtract as part of its instruction set.
 - Most microprocessors will have operations such as multiply and divide.
 - Some of the newer ones will have complex operations such as square root.
- In addition, microprocessors have logic operations as well. Such as AND, OR, XOR, shift left, shift right, etc.
- Again, the number and types of operations define the microprocessor's instruction set and depends on the specific microprocessor.

Definition (Contd.)

– Stored in memory :

- First, what is memory?
 - Memory is the location where information is kept while not in current use.
 - Memory is a collection of storage devices. Usually, each storage device holds one bit. Also, in most kinds of memory, these storage devices are grouped into groups of 8. These 8 storage locations can only be accessed together. So, one can only read or write in terms of bytes to and from memory.
 - Memory is usually measured by the number of bytes it can hold. It is measured in Kilos, Megas and lately Gigas. A Kilo in computer language is $2^{10}=1024$. So, a KB (KiloByte) is 1024 bytes. Mega is 1024 Kilos and Giga is 1024 Mega.

Definition (Contd.)

– Stored in memory:

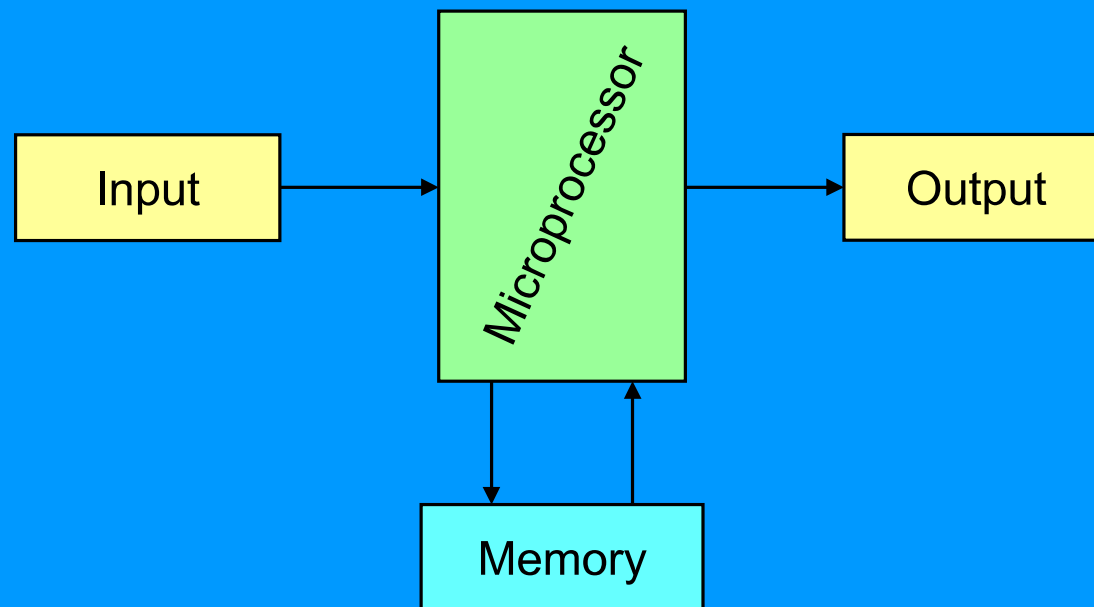
- When a program is entered into a computer, it is stored in memory. Then as the microprocessor starts to execute the instructions, it brings the instructions from memory one at a time.
- Memory is also used to hold the data.
 - The microprocessor reads (brings in) the data from memory when it needs it and writes (stores) the results into memory when it is done.

Definition (Contd.)

- **Produces:** For the user to see the result of the execution of the program, the results must be presented in a human readable form.
 - The results must be presented on an output device.
 - This can be the monitor, a paper from the printer, a simple LED or many other forms.

A Microprocessor-based system

From the above description, we can draw the following block diagram to represent a microprocessor-based system:

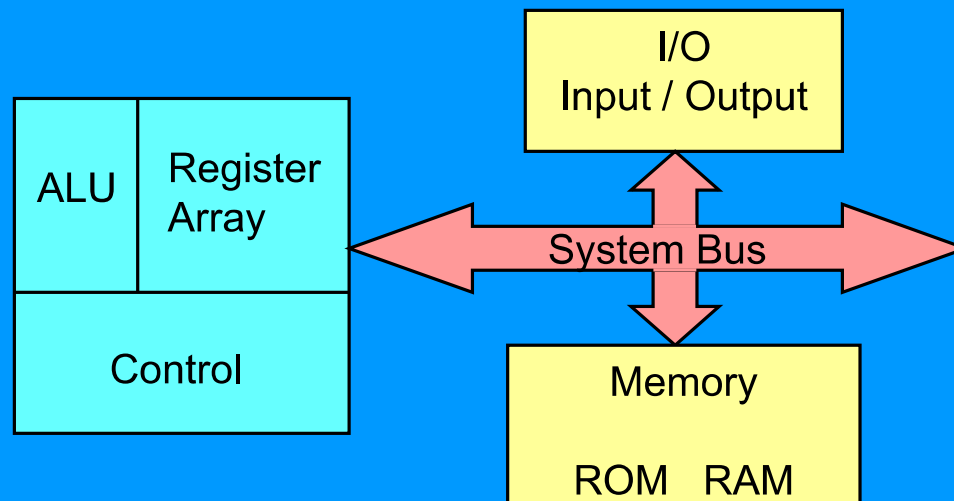


Inside The Microprocessor

- Internally, the microprocessor is made up of 3 main units.
 - The Arithmetic/Logic Unit (ALU)
 - The Control Unit.
 - An array of registers for holding data while it is being manipulated.

Organization of a microprocessor-based system

- Let's expand the picture a bit.

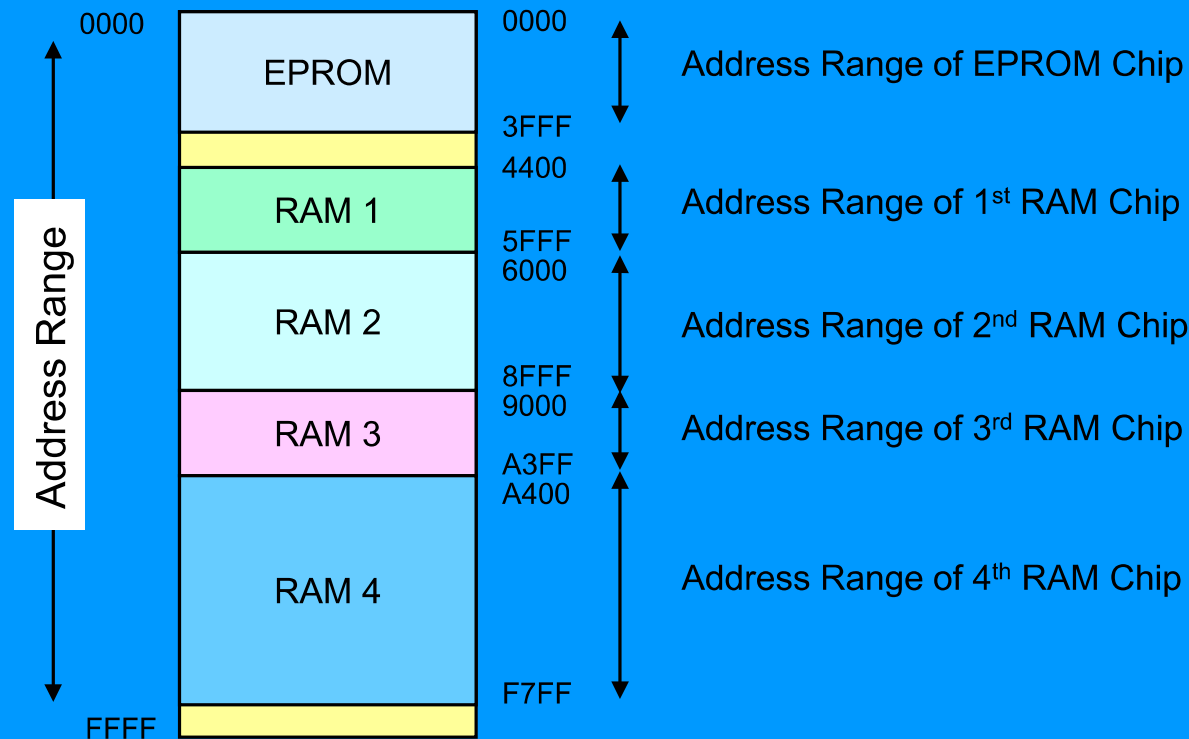


Memory

- Memory stores information such as instructions and data in binary format (0 and 1). It provides this information to the microprocessor whenever it is needed.
- Usually, there is a memory “sub-system” in a microprocessor-based system. This sub-system includes:
 - The registers inside the microprocessor
 - Read Only Memory (ROM)
 - used to store information that does not change.
 - Random Access Memory (RAM) (also known as Read/Write Memory).
 - used to store information supplied by the user. Such as programs and data.

Memory Map and Addresses

- The memory map is a picture representation of the address range and shows where the different memory chips are located within the address range.



Memory

- To execute a program:
 - the user enters its instructions in binary format into the memory.
 - The microprocessor then reads these instructions and whatever data is needed from memory, executes the instructions and places the results either in memory or produces it on an output device.

The three cycle instruction execution model

- To execute a program, the microprocessor “reads” each instruction from memory, “interprets” it, then “executes” it.
- To use the right names for the cycles:
 - The microprocessor fetches each instruction,
 - decodes it,
 - Then executes it.
- This sequence is continued until all instructions are performed.

Machine Language

- The number of bits that form the “word” of a microprocessor is fixed for that particular processor.
 - These bits define a maximum number of combinations.
 - For example an 8-bit microprocessor can have at most $2^8 = 256$ different combinations.
- However, in most microprocessors, not all of these combinations are used.
 - Certain patterns are chosen and assigned specific meanings.
 - Each of these patterns forms an instruction for the microprocessor.
 - The complete set of patterns makes up the microprocessor’s machine language.

The 8085 Machine Language

- The 8085 (from Intel) is an 8-bit microprocessor.
 - The 8085 uses a total of 246 bit patterns to form its instruction set.
 - These 246 patterns represent only 74 instructions.
 - The reason for the difference is that some (actually most) instructions have multiple different formats.
 - Because it is very difficult to enter the bit patterns correctly, they are usually entered in hexadecimal instead of binary.
 - For example, the combination 0011 1100 which translates into “increment the number in the register called the accumulator”, is usually entered as 3C.