An Overview of Microprocessor

The first question comes in a mind "What is a microprocessor?". Let us start with a more familiar term computer. A digital computer is an electronic machine capable of quickly performing a wide variety of tasks. They can be used to compile, correlate, sort, merge and store data as well as perform calculations.

A digital computer is different from a general purpose calculator in that it is capable of operating according to the instructions that are stored within the computer whereas a calculator must be given instructions on a step by step basis. By the definition a programmable calculator is a computer.

Historically, digital computers have been categorized according to the size using the words large, medium, minicomputer and microcomputer. In the early years of development, the emphasis was on large and more powerful computers. Large and medium sized computers were designed to store complex scientific and engineering problems. These computers were accessible and affordable only to large corporations, big universities and government agencies. In the 1960s’ computers were accessible & affordable only to large corporations, big universities & government agencies, In late 1960s, minicomputers were available for use in a office, small collage, medium size business organization, small factory etc. As the technology has advanced from SSI to VLSI & SLSI (very large scale integration & super large scale integration) the face of the computer
has changed. It has now become possible to build the control processing unit (CPU) with its related timing functions on a single chip known as microprocessor. A microprocessor combined with memory and input/output devices forms a microcomputer. As far as the computing power is concerned the 32-bit microcomputers are as powerful as traditional mainframe computers.

The microcomputer is making an impact on every activity of mankind. It is being used in almost all control applications. For example analytical and scientific instruments, data communication, character recognition, musical instruments, household items, defence equipments, medical equipments etc.

Computers communicate and operate in binary numbers 0 and 1 also known as bits. It is the abbreviation for the term binary digit. The bit size of a microprocessor refers to the number of bit which can be processed simultaneously by the arithmetic circuit of the microprocessor. A number of bits taken as a group are this manner is called word. For example, the first commercial microprocessor the Intel 4004 which was introduced in 1971 is a 4-bit machine and is said to process a 4-bit word. A 4-bit word is commonly known as nibble and an 8-bit word is commonly known as byte. Intel 8085 is an 8-bit microprocessor. It should be noted that a processor can perform calculations involving more than its bit size but takes more time to complete the operation. The short word length requires few circuitry and interconnection in the CPU.
**Microcontrollers**

A µP does not have enough memory for program and data storage, neither does it have any input and output devices. Thus when a µP is used to design a system, several other chips are also used to make up a complete system. For many applications, these extra chips imply additional cost and increased size of the product. For example, when used inside a toy, a designer would like to minimize the size and cost of the electronic equipment inside the toy. Therefore, in such applications a microcontroller is used more often than a microprocessor.

A microcontroller is a chip consisting of a microprocessor, memory and an input/output device. There are 4 bit as well as 32 bit microcontrollers.

**Evolution of the Microprocessors**

The history of the µP development is very interesting. The first µP was introduced in 1971 by Intel Corporation. This was the Intel 4004, a processor on a single chip. It had the capability of performing simple arithmetic and logical operations. E.g. Addition, subtraction, comparison, logical AND and OR. It also had a control unit which could perform various control functions like fetching an instruction from the memory, decoding it and generating control pulses to execute it. It was a 4 bit µP operating on 4 bits of data at a time. The processor was the central component in the chip set, which was called the MCS-4. The other components in the set were a 4001
ROM, 4002 ROM and a 4003 shift register.

Shortly after the 4004 appeared in the commercial market place, there is other general purpose µP were introduced. These devices were the Rockwell International 4 bit PPS-4, the Intel 8 bit 8008 and the National Semiconductor 16 bit IMP-16. Other companies had also contributed in the development of µP.

The first 8 bit µP, which would perform arithmetic and logic operations on 8 bit words, was introduced in 1973, by Intel. This was 8008 that was followed by an improved version- the 8080 from the same company. The µPs introduced between 1971and 1972 were the first generator systems. They were designed using the PMOS technology. This technology provided low cost, slow speed and low output currents and was compatible with TTL.

After 1973, the second generation µPs such as Motorola 6800 and 6809, Intel 8085 and Zilog Z80 evolved. These µPs were fabricated using NMOS technology. The NMOS process offered faster speed and higher density than PMOS and was TTL compatible. The distinction between the 1st & 2nd generation devices was primarily the use of new a semiconductor technology to fabricate the chips. This new technology resulted in a significant increase in instruction execution speed & higher chip densities.

After 1978, the 3rd generation microprocessors were introduced. Typical µPs are Intel 8086/80186/80286 and Motorola 68000/68010. These µPs were designed using HMOS technology. HMOS provides the following advantages over NMOS.
1) Speed power produced (SSP) of HMOS is 4 times better than that of NMOS. That is for NMOS, SSP is 4 picojoules (PJ) and for HMOS, SSP is 1 picojoules (PJ).

\[ \text{Speed power product} = \text{speed} \times \text{power} = \text{nanoseconds} \times \text{mill watt} = \text{picojoules} \]

2) Circuit densities provided by HMOS are approximately twice those of NMOS. That is for NMOS. It is 4128 $\mu m^2$/gate and for HMOS it is 1052.5 $\mu m^2$/gate, where $1\ \mu m = 10^{-6}$ meter.
Later, Intel initialized the HMOS technology to fabricate the 8085A. Thus, Intel offers a high speed version of the 8085A called 8085AH.

The third generation introduced in 1978 is typically separated by the Intel 8086 iAPX 8086 iAPX 80186, iAPX 80286 Zilog 78000, and the Motorola 68000 which are 16-bit \( \mu P \)'s with minicomputer like performances. One of the most popular 16 bit \( \mu P \) has been introduced by Intel, which is 8088. The 8088 has the same introduction set as the 8088. However, it has only an 8 bit data bus. The 8088 is the \( \mu P \) used in the IBM PC and its clones. A precursor to these microprocessors was the 16-bit Texas instruments 9900 microprocessor introduced in 1976. The latest microprocessor has the word length of 32-bit. Example of 32-bit microprocessors are Intel iAPX 80386, iAPX 432, Motorola MC68020, National semiconductor NS 32032. The characteristic for few microprocessors introduced by Intel are given in the Table. This shows that power of microprocessors has increased tremendously with advancement in integrated circuit technology & microprocessor systems architecture. Very large & cute integration, VLSI allow extremely complex system consisting of as many as a million of transistors on a single chip to be realized.

In 1980, the fourth generation \( \mu P \)s were evolved. Intel introduced the first commercial 32 bit microprocessor, Intel 432. This \( \mu P \) was discontinued by Intel due to some problem. Since 1985, more 32bit \( \mu P \)s have been introduced. These include the Motorola MC
68020/68030/68040 and Intel 80386/80486. These processors are fabricated using the low power version of HMOS technology called HCMOS, and they include an on-chip RAM called the cache memory to speed up program execution.

Table evaluation of major characteristics.

<table>
<thead>
<tr>
<th></th>
<th>4004</th>
<th>8008</th>
<th>8085A</th>
<th>8086</th>
<th>80386</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>71</td>
<td>71</td>
<td>77</td>
<td>78</td>
<td>85</td>
</tr>
<tr>
<td>Lass</td>
<td>4-bit</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Technology</td>
<td>PMOS</td>
<td>PMOS</td>
<td>NMOS</td>
<td>HMOS</td>
<td>CHMOS</td>
</tr>
<tr>
<td>Record size data/must</td>
<td>4/8</td>
<td>8/8</td>
<td>8/8</td>
<td>16/16</td>
<td>32/32</td>
</tr>
<tr>
<td>Address capacity</td>
<td>4K</td>
<td>16K</td>
<td>64K</td>
<td>1M</td>
<td>4G</td>
</tr>
<tr>
<td>Clock kHz/phase</td>
<td>740/2</td>
<td>800/2</td>
<td>6250/2</td>
<td>8000/2</td>
<td>16000/2</td>
</tr>
<tr>
<td>Add time</td>
<td>10.8μs</td>
<td>20μs</td>
<td>1.3μs</td>
<td>0.37μs</td>
<td>0.125μs</td>
</tr>
<tr>
<td>Internal reg. al/gp</td>
<td>1/16</td>
<td>1/6</td>
<td>1/6</td>
<td>1/8</td>
<td>1/8</td>
</tr>
<tr>
<td>Tale size</td>
<td>3*12</td>
<td>7*14</td>
<td>RWM</td>
<td>RWM</td>
<td>RWM</td>
</tr>
<tr>
<td>Records/ bits</td>
<td>150-10,5*</td>
<td>-9.5v</td>
<td>+5V</td>
<td>+5V</td>
<td>+5V</td>
</tr>
<tr>
<td>Voltages</td>
<td>16pin</td>
<td>18pin</td>
<td>40pin</td>
<td>40pin</td>
<td>132pin</td>
</tr>
<tr>
<td>Package size introduction</td>
<td>45</td>
<td>48</td>
<td>74</td>
<td>133</td>
<td>135</td>
</tr>
<tr>
<td>Transition</td>
<td>2300</td>
<td>2000</td>
<td>6200</td>
<td>29000</td>
<td>275000</td>
</tr>
<tr>
<td>Chip size (mil)</td>
<td>117*159</td>
<td>125*170</td>
<td>164*222</td>
<td>225*230</td>
<td>390*390</td>
</tr>
</tbody>
</table>
The performance offered by a 32 bit µP is more comparable to that of super computers such as VAX 11. Recently, Intel and Motorola introduced a 32 bit RISC (Reduced Instruction Set Computer) µP (Intel 80960 and Motorola 88100) with a simplified instruction set. The trend in µPs is not toward introduction of 64 bit µPs. Extensive research is being carried out for implementation of more on chip functions and for improvement of the speed of the memory and I/O devices; i.e. microcontrollers.
**Intel 8085 Microprocessor**

It is a 40-pin DIP(Dual in package) chip, base on NMOS technology, on a single chip of silicon. It requires a single +5v supply between Vcc at pin no 40 and GND at pin no 20. It can address directly $2^{16}$ memory locations or 6536 memory locations or 64k memory locations using 16 address line ($A_{15}-A_0$).
Pin no 28 to 21 gives as the higher order 8 bits of the address \((A_{15}-A_8)\). these 8- address lines are uni-directional tri-state address lines these address lines becomes tri-state under three conditions namely.

(a) During DMA (direct memory access) operation
(b) When a HALT instruction is executed
(c) When \(\mu P\) is being RESET.

\(A_{15}-A_8\) at pin no 19 to pin no 12 → pin no 19 to pin no 12, marked \(A_7-A_0\) is used for dual purpose. The \(\mu P\) during it operation shall move from one state to the other. There are ten (10) different states for the \(\mu P\) namely.

1. **RESET STATE** → \((T_{\text{RESET}})\) → \(\mu P\) can be in \(T_{\text{RESET}}\) state for an integral multiple clock cycle.

2. **WAIT STATE** → \((T_{\text{WAIT}})\) → it can be in this state for an integral no of clock cycle. The duration being determined by an external control signal input marked READY.

3. **HOLD STATE** → \((T_{\text{HOLD}})\) → \(\mu P\) depends upon the external control signal input HOLD.

4. **HALT STATE** → \((T_{\text{HALT}})\) → \(\mu P\) enter there state when an ILT instruction is executed by \(\mu P\) it remains in this state till such time when an external signal dictated by the use asked the \(\mu P\) to perform further duties.

5. The other states, the \(\mu P\) can be IN are marked \(T_1, T_2, T_3, T_4, T_5\) & \(T_6\) states each of them states are of one clock period duration each of there states clearly identifies the predetermined timing.
slots  \(T_1, T_2, T_3, T_4, T_5\) & \(T_6\) \(\mu P\) perform specific very well defined activities during these states.

**Pin Configuration of Intel 8085A Microprocessor:**

Pin no 19 to pin no 12 shall be utilize by the \(\mu P\) to sent lower order bits of the 8\(^{16}\) –bit of information during \(T_1\) timing slots and therefore, the same 8-points shall be utilized as bi-directional data bus (BDB) for data transfer operation in the subsequent timing slots \(T_2\) & \(T_3\). Hence these pins are designated AD\(_7\) to AD\(_6\).

These 8- lines are also tri-state line they will be tri-stated during \(T_4\), \(T_5\) & \(T_6\) states. They will also be tri-stated during DMA operation and when a HALT instruction is executed. These lines will also be tri-stated for a very-short duration of time (few neon sec) between \(T_1\) & \(T_2\) states.

**ADDRESS LATCH ENABLE (ALE) AT PIN NO 30**

it is a single pulse issued every \(T_1\) state of the \(\mu P\) as shown on fig-2. since the lower order 8-bits of the address information A\(_7\) to A\(_0\) is available at pin no 19 to 12, when ALE pulse exists at pin no 30. We can use these information to latch the lower order bits of the address externally using (say) an 8212 register latch once save on an external latch the lower order address A\(_7\) to A\(_0\) shall be available at the output of the register latch for the subsequent states \(T_2\), \(T_3\), \(T_4\), \(T_5\) & \(T_6\), while pin no 19 to 12 can then be utilized by the \(\mu P\) for bi-directional operation.
The manner of utilization of pins 19 to 12 is known as time multiplexed mode of operation.

**De multiplexing the Address bus AD<br>– AD**:  

The 8085 A uses a multiplexed address-data bus. This is due to limited number of pins on the 8085A-IC. Low-order 8-bits of the memory address (or I/O address) appear on the AD bus during the first clock cycle. (T1 state of an m/c cycle) It then becomes the data bus during the second and third clock cycles (T2 and T3 states). ALE, address latch enable signal occurring during the T1 state of a m/c cycle is used to latch the address into the on-chip latch of certain peripherals such as 8155/8156/8355/8755A. These chips ALE input pin is connected to the ALE output pin of the 8085 A, thus allowing a direct interface with the 8085 A. Thus IC chips internally de multiplex the AD bus using the ALE signal. Since a majority of peripheral devices do not have the internal multiplexing facility, there is external hardware necessity for it.

Fig. shows a schematic that uses a latch and the ALE signal to de multiplex the bus. The bus AD– AD is connected as the input to the latch 74LS373. The ALE signal is connected to the enable (G) pin.
of the latch, and the output control (OC) signal of the latch is grounded. When ALE goes high during the T_1 state of a m/c cycle, the latch is transparent in the output of the latch changes according to the input. The CPU is putting lower-order bits of address during this time. When the ALE goes LOW, the address bits get latched on the output and remain so until the next ALE signal.

![Diagram](image)

**Read & Write Control signals at pin no 32 & pin no 31**

Read & Write Control signals at pin no 32 & pin no 31

The BDB at pin no 19 to 12 are used for bi-directional data transfer operation T_2 & T_3 states when the BDB is inputting the information from the external world into the μP, we say that μP is in READ MODE and operation is READ operation. When the μP is outputting 8-bit of information to the external world through BDB we have a WRITE operation μP is in OUTPUT MODE or WRITE MODE. To tell the external world that μP is in WRITE MODE, μP Issues a control signal output at pin no 31 it is normally HIGH & becomes active & LOW.

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It goes LOW during $T_2$ state and goes HIGH again during $T_3$ state of the. This is shown in fig.3

When the BDB is in the input mode for READ operation, the control signal. Output goes Low during $T_2$ state and goes HIGH during $T_3$ state. Note that the normal state of is HIGH. Also note that for obvious reasons are not made active LOW simultaneously. Note further whenever, the BDB is made to be in the INPUT MODE by the $\mu P$, it issues the $\overline{RD}$ control signal output by making it active LOW as described and it is for the user to beep the appropriate 8-bit data either from the memory or
from a peripheral device at this appropriate time similarly
during a WRITE operation first send the desired address
in the address lines during T₁ states. Thereafter, if places the
desired 8-bit data on the BDB which is na in the output mode
and then issues the control signal output as
described. It is for the user to take appropriate action externally by it
interfacing circuitry so that the data so placed goes to the appropriate
device.

**IO/M at pin no 34**

O/M is an output tri-state control signal. It is active both way
whenever the address issued by the on the address lines refers to
the memory then the makes IO/M LOW throughout T₁,T₂,T₃,T₄,T₅
& T₆ states to indicate the external world that the address so sent
belongs to the memory and data on the BDB refers to the memory.
Whenever the address in the address lines. Refers to an I/O device
the makes IO/M control signal output HIGH to tell the external
world that the address in the address lines refer to I/O device and the
data in the BDB refers to an I/O device.

Note that IO/M signal is LOW or HIGH as the case may be
throughout six timing slots T₁,T₂,T₃,T₄,T₅ & T₆ states. It is for the user
to make use of the facilities give to develop proper interfacing
circuitry.
Microcontroller

Contents
• Introduction
• Inside 8051
• Instructions
• Interfacing

Introduction
• Definition of a Microcontroller
• Difference with a Microprocessor
• Microcontroller is used wherever

Definition
• It is a single chip
• Consists of Cpu, Memory
• I/O ports, timers and other peripherals

Difference

**MICRO CONTROLLER**
• It is a single chip
• Consists Memory, I/O ports

**MICRO PROCESSER**
• It is a cpu
• Memory, I/O Ports to be connected externally.

Where ever
• Small size
• Low cost
• Low power