Lecture-I

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 for 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.

Microcomputers:

In a very general a microcomputer is best regard as a system incorporating a CPU and assisted hardware whose purpose is to manipulate data in same fashion. This is exactly what any digital

circuit designed using SSI's and MSI's will also do therefore, microcomputer should be regard as a general purpose logic device. In contrast to standard SSI's and MSI's where the manufacturer decides what the device will do, with microcomputer it is the user who decides what the device should do by asking it to execute a proper set of instructions. A microcomputer, from this point of view is merely an assembly of devices whose sole task is to ensure that the instruction desire are indeed carried out properly and to allow the microprocessor to communicate with the real world, i.e. the user environment. The power of the microcomputer lies in the fact that if the application change, the same system can still used by appropriately modifying the instruction to be executed and if necessary some changes in the hardware. In contrast, a digit circuit designed using SSI's and MSI's for same application will need to be completely redesigned if the application changes significantly.

The objective of a microcomputer is to manipulate data in a certain fashion specified by the system designer. A typical microcomputer achieves their objective by getting its CPO (µp) to execute a number of instructions in the proper sequence. This sequence of instruction comprises the program that is executed by the micro computer.

A microcomputer which does nothing other than manipulate data present within itself, Will not be of much use to anybody. In order to do something meaningful, data being manipulated should depend on same fashion on input provided to the microprocessor would be completely senseless unless the results of these manipulations affects things outside the µc itself. A µc should on its input, the which

in same way, depends on its input, the way input and output are related is decided by the program that gets executed.

Therefore, a µc is an assembly of devices including a CPU, which manipulate data depending on one or more inputs and according to a program, in order to generate one or more output.

There are several standards for logic '1' and logic '0'.

A) TTL logic	0V-0.8 V	→	logic '0'
	2.4 V-5.2V	→	logic '1'
B) 20 mA current loop	Zero current	→	logic '0'
	20 mA current	→	logic '1'
C) RS-232 C	+3V to +15V	→	logic '0'
	-5V to +15V	→	logic '1'

For microprocessor and most of its peripherals, TTL logic levels are used. 20 mA current loops are used for TTY and RS-232 C is used for serial data communication.

Microcontrollers

A µP does not have enough memory for program and data storage, neither does it has 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 1^{st} & 2^{nd} 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 3^{rd} 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).

   Speed power product = speed * power
   = nanoseconds * mill watt
   = picojoules

2) Circuit densities provided by HMOS are approximately twice those of NMOS. That is for NMOS. It is 4128 μm^2/gate and for HMOS it is 1052.5 μm^2/gate, where 1 μm = 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 μP_s with minicomputer like performances. One of the most popular 16 bit µP 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 µP 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 µPs were evolved. Intel introduced the first commercial 32 bit microprocessor, Intel 432. This µP was discontinued by Intel due to some problem. Since 1985, more 32bit µPs 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 μp characteristics.

	4004	**8008**	**8085A**	**8086**	**80386**
Data	71	71	77	78	85
Lass	4-bit	8	8	16	32
Technology	PMOS	PMOS	NMOS	HMOS	CHMOS
Record size data/ must	4/8	8/8	8/8	16/16	32/32
Address capacity	4K	16K	64K	1M	4G
Clock kHz/phase	740/2	800/2	6250/2	8000/2	16000/2
Add time	10.8μ s	20 μ s	1.3 μ s	0.375 μ s	0.125 μ s
Internal reg. al/gp	1/16	1/6	1/6	1/8	1/8
Tale size	3*12	7*14	RWM	RWM	RWM
Records/ bits	150-10,5*	-9.5v	+5V	+5V	+5V
Voltages	16pin	18pin	40pin	40pin	132pin
Package size introduction	45	48	74	133	135
Transition	2300	2000	6200	29000	275000
Chip size (mil)	117*159	125*170	164*222	225*230	390*390
Manufactures	Intel	Intel	Intel	Intel	Intel

The performance offered by a32 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.