Micro-Processor Introduction

Introduction to Microprocessor

Learning Objectives

After reading this unit you should appreciate the following:

- Introduction to Microprocessor
- Evolution of Microprocessor
- Overview of Intel Pro-Pentium
- Motorola 68000 Series
- Introduction to DEC Alpha, Power PC
- RISC & CISC Architecture

Introduction

Microprocessor acts as a CPU in a microcomputer. It is present as a single IC chip in a microcomputer.

Microprocessor is the heart of the machine.

A Microprocessor is a device, which is capable of

1. Receiving Input

2 Performing Computations

3. Storing data and instructions

4. Display the results

5. Controlling all the devices that perform the above 4 functions.

The device that performs tasks is called Arithmetic Logic Unit (ALU). A single chip called Microprocessor performs these tasks together with other tasks.

A MICROPROCESSOR is a multipurpose programmable logic device that reads binary instructions from a storage device called memory accepts binary data as input and processes data according to those instructions and provides results as input

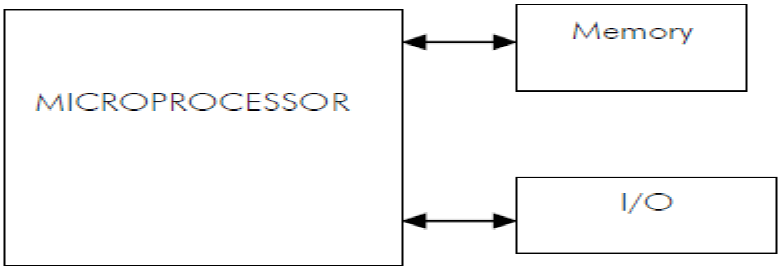


Figure 1.1

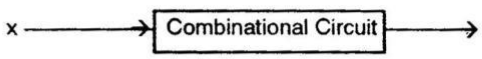
Figure shows a programmable machine, which consists of a microprocessor, memory, I/O.

All these three-component work together to perform a given task.

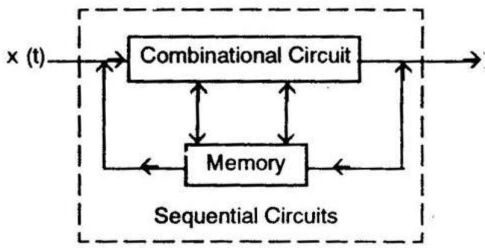
The digital circuits and systems can be broken into:

Combinational Circuits: and

Sequential Circuits



Example : Logic GATES



! "

Example: Flip-Flops Registers, Counters etc

It is the notion that the digital circuits and systems are the by product of the Boolean functions. Let any
Boolean function be expressed as:
f_{ki} (A,B,C,D ……….).

Where, k ⟶ Number of Boolean Variables,

and i ⟶ Total Boolean functions generated by these variables.

If, for example, k = 4, then i = 2^4 15
= 0,1 .

Hence, a Boolean function can be expressed as:

f_{ki} (A,B,C,D)
where i =
0,1....... 15.

Example: Consider a function as:

$F_{41}(A,B,C,D)=AB+\bar{B}C+CD+\bar{A}B$

Here k = 4, and i = 1

This function can be realized in a number of ways depending upon the types of the technologies used:

(i) Discrete Element: The use of discrete element for realizing any function was the first technology used before 1960 and had to generate each Boolean variable by discrete elements to realize the whole function.

In this method, each variable was realised independently and these are combined to get the functions. The performance of the assembled circuit depended upon the individuals how neatly he could do it apart from the complexity of the circuit. It required often much more time for assembling and every one had to assemble it separately in hi$ own way. This created problems in automated working environment.

(ii) SSI: The innovation in the semiconductor technology forced the scientists & engineers to think many a times to put them as a package either in the form of a single IC or in hybrid form. In the year 1965, the development of Integrated circuit technology came into existence which gave the possibility of packing 100 transistors on the single chip. By this time the two technologies, namely, SSI (< 10) and MSI (< 100) were used to generate and realise functions. In SSI technology, AB, B’C, CD, A’B were generated independently for realising the whole function. Thus, SSI required 5 - chips, one each for AB, B’C, CD, A’B, and AB +B’C+CD+A’B.

(iii) MSI: In the MSI technology, AB+B’C and CD+A’B were generated independently for realising the whole function. Thus in SSI technology more than 4-chips were required whereas in MSI technology (just) more than 2-chips were required for realising the same function. This technology was used between 1965 to 1970.

(vi) LSI: The continued search in semiconductor technology resulted into realisation of more functions due to high packing density. Hence the LSI technology further increased the facility of packing transistors on a single chip upto a few thousands. With this technology, whole functions could be realised with only one chip. For large values of k, the function became more complicated and it may not be possible to realise the whole function by a single chip. The continued search in the semiconductor technology resulted in the development of the VLSI technology wherein many more components could be packed on a single chip.

The continued development of IC technology resulted in realization of more complicated functions with better reliability, compactness, low cost and low power dissipation. Figure 1.2. shows different stages of integration. Chips such as counters, memory devices, etc. were developed using MSI and LSI technologies. With passage of time, the IC technology developed at an incredible pace and all Boolean functions could be realized on a single chip. The chip capable of processing all Boolean functions was given the name of Processor. On the same line, the chip which processed the data in a controlled manner was called the microprocessor.

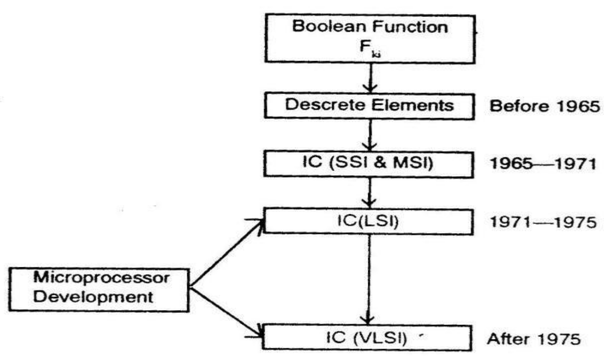


Figure 1.2 Microprocessor Family Development

There were people who said that the microprocessor was the accidental by product of the general procedure for 'manufacturing the high density semiconductor memories using MOS-LSI technology. At the end of the 1960-70 decade, the need for the type of technology which placed thousands of transistors on a single chip became obvious. However, it was not yet completely clear as to which function could use so many devices effectively. Memories, of course, were one among such functions. With the design and development of such semiconductor memories, the need of an equally complex and efficient processor was felt which not only were able to use them effectively, but could pave the way for the selling of semiconductor memories easily.

The microprocessor age began with the advancement in the IC technology to put all necessary functions of a CPU into a single chip. Advancement in semiconductor technology increased the capacity to include more and more logic on a single chip. Although the cost of the microprocessor increased with its complexities, yet it was much lower than the cost of the equivalent logic scattered over several less capable chips. In addition to reduced number of ICs needed to perform a given function, the total number of pins are reduced and hence assembly cost was also reduced.

1st Generation Microprocessor

At the end of the 70s a group of engineers developed a chip capable of processing data. This chip was given the name, processor chip. The large processors were developed using VLSI technology. Another successful attempt of engineers, in developing a processor which worked in a controlled manner, was given the name of microprocessor. Thus a single LSI/ VLSI/VVLSI chip, capable of processing data in a controlled manner was called the microprocessor.

The design team headed by Ted Hoff of Intel Corporation developed the 1st such controlled processor in the year 1969, but Intel started marketing its first microprocessor in the name of Intel 4004 in 1971. This was a 4-bit microprocessor having 16-pins hocused in a single chip of pMOS technology. This was called the first generation microprocessor. The 4-bit microprocessor worked with 4-bit word .The Intel 4004 along with few other devices was used for making calculators. The ability of changing functions of any system by just changing the programming rather than redesigning the hardware was the key behind the evolution of the microprocessors.

The Intel 8008 was developed in the year 1972 that worked with 8-bit word.

It required about 20 or more additional devices(chips) to design a functional CPU.

A few first generation microprocessors are listed in Table 1.1.

Table 1.1

Microprocessor	Word Size	Microprocessor	Word Size
INTEL 4004 &4040	4- bit	INTEL 8008	8-bit
FAIRCHILD PPS-25	" "	NATIONAL IMP-8	" "
NATIONAL IMP-4	" "	ROCKWELL PPS	" "
ROCKWELL PPS-4	" "	AMI 7200	" "
MICROSYSTEM	" "	MOSTEK 5065	" "

Types of Microprocessors

Microprocessors fall into three categories:

- Single Chip Microcomputers ® Contains microprocessor, ROM, RWM, I/O port, clock and timer.
- General purpose microprocessor.
- Bit slice microprocessor.

The general-purpose microprocessor contain ALU with one or more registers which functioned as accumulator, a control unit, an instruction decoder which handled a fixed instruction set and general and special purpose registers which varied significantly from microprocessor to microprocessor. A microprocessor may have an internal stack of fixed length or use external memory for stack. The general purpose microprocessor are available of word lengths of 1, 4, 8, 16, 32, and 64 bits.

The Bit slice microprocessor divide the functions of ALL, general purpose and special purpose registers and control unit into several ICs. For this general purpose registers and ALU were packed in separately from controls. Each register of ALU (RALU) package was essentially equivalent to 2 or 4-bit wide slice of registers and the ALU of the microprocessor. Bit slice processor could be cascaded to produce any unconventional or conventional word length of the microprocessor such as 4, 8, 10, 12, 16, 32 or higher bits. The control portion of bit slice processor was constructed from microprocessor sequencer IC and other logics.

IInd Generation Microprocessor

The second generation microprocessor using nMOS technology appeared in the market in the year 1973.

Table 1.2: List of 2nd generation microprocessors.

Microprocessors	Word Size
INTEL 8080 / 8085	8 - bit
FAIRCHILD F8	" "
MOTOROLA M 6800	" "
NATIONAL CMP-8	" "
RCA COSMAC	" "
MOS Tech. 6500	" "
SIGNETICS 2650	" "
ZILOG Z-80	" "
INTERSIL 6100	12-BIT
TOSHIBA TLCS-12	" "

The Intel 8080, an 8-bit microprocessor, of nMOS technology was developed in the year 1974 which required only two additional devices to design a functional CPU. Since 8080 was nMOS device, it was much faster and had many more instructions than 8008 that facilitated the programming. The advantages of

IInd generation microprocessors were

- Large chip size (170x200 mil) with 40-pins.
- More chips on decoding circuits.
- Ability to address large memory space (64-K Byte) and I/O ports(256).
- More powerful instruction sets.
- Dissipate less power.
- Better interrupt handling facilities.
- Cycle time reduced to half (1.3 to 9 m sec.)
- Sized 70x200 mil) with 40-pins.
- Less Support Chips Required
- Used Single Power Supply
- Faster Operation

IIIrd Generation Microprocessor

The single chip 3rd generation microprocessor having 64-pins started with the introduction of 16-bit Intel 8086 in the year 1978. The other important IIIrd generation microprocessors were Zilog Z-8000, Motorola M68000, National NS16016, and Texas Instruments TMS 99000 series, etc. The 16-bit microprocessor using HMOS technology achieved enhanced performance parameters w.r.t. the 8-bit microprocessors. In addition to enhanced performance, it contained multiply/divide arithmetic hardware. The memory addressing capabilities were increased i.e. IM Byte to 16 Mbyte through a variety of flexible and powerful addressing modes.

Intel 8088 was identical to 8086 but for the 8-bit data bus. Hence 8088 could read orwrite8-bits data at a time to or from the memory. The Intel 80186 and 80188 were the improved versions of Intel 8086 and 8088, respectively. In addition to 16-bit CPU, the 80186 and 80188 had programmable peripheral devices integrated on the same package. The program written for 80186 and 80188 may not work well on 8086 and 8088, but those written for 8086 and 8088 worked without much difficulties on 80186 and 80188. This means they were upward compatible with 8086 and 8088. The Intel 80286 was the advancedversionof80186. It is designed for use in multi-user/ multitasking environment.

IVth Generation Microprocessor

The single chip 32-bit microprocessor was introduced in the year 1981 by Intel as iAPX 432. The other 4th generation microprocessors were; Bell Single Chip Bellmac-32, Hewlett-Packard, National NSl 6032, Texas Instrument99000. Motorola 68020 and 68030.

The power of the microprocessor went on increasing with the advancement in the integrated circuit technology. The VLSI technology culminated in the extremely complex microprocessor with as many as one billion transistors on a single chip. The Intel in the year 1985 announced the 32-bit microprocessor (80386). The 80486 has already been announced and is also a 32-bit microprocessor.

Most of the microprocessors were manufactured with HMOS(high density short channel MOS) technology because of the following advantages:

(i) Speed-power product was 4-times greater than NMOS. Its typical value was I-pico joule whereas it was 4-pico joules in the case of NMOS technology.

(ii) Circuit density was approximately 2-times greater than NMOS. The typical NMOS density was 4128um2 gate whereas it was 1852.5 um2 for HMOS.

Tabular comparison for μ PS' Parameters

Tables 1.3 (a) and (b) list the characteristic of some Intel microprocessor.

Table 1.3(a)

	8008	8080	8085	8086	80286	80386
Supply	+5V,-9V	+5V&12V	+5V	+5V	+5V	+5V
Year	1972	1974	1976	1978	1982	1985
No.of transistors	2000	4500	6500	20000	—	2,75,000
Pinouts	18	40	40	40	68	132
Technology	PMOS	NMOS	NMOS	HMOS	HMOS	CHMOSIII
Word Size	8	8	8	16	16	32
Direct addressing	16KB	64KB	64KB	1MB	16MB	4GB
Basic 1instructions	48	78	80	97	97	151
GPRs	6	8	8	16	16	8
Max CLK (MHz)	0.8	2.6	5.5	5*	10	24
Gate Delay	30ns	15ns	3ns	3ns	—	—

** 8086-1=10MHz & 8086 6-2=8MHz

Table 1.3(b): Microprocessors Characteristics

Features	38080 3MCS80	8085 MCS8085	8086 iAPX86	8088 iAPX88	80186 iAPX186	80188 iAPX188	80286 iAPX286	80386 iAPX386
Bus inter face (bits)	8	8	16	8	16	8	16	32 & 16
Internal data path	8 Bits	8 Bits	16 Bits	16 Bits	16 Bits	16 Bits	16 Bits	32 Bits
CLK(speed selection	2,2.6 & 3 MHz	3,5 & 6 MHz	5,8 & 10 MHz	5 & 8 MHz	6 & 8 MHz	6 & 8 MHz	6,8 & 10 MHz	12 & 16 MHz
Bus BW (max.)	0.75 Byte/s	1.5M Byte/s	5M Byte/s	2M Byte/s	4M Byte/s	2M Byte/s	10M Byte/s	32M Byte/s
R<->R Add time/word	1.3 μs	0.67 μs	0.3 μs	0.38 μs	0.3 μs	0.3 μs	0.2 μs	125 ns
INTR response time	7.3 μs	2 μs	6.1 μs	8.6 μs	5.25 μs	8.3 μs	3.5 μs	μs
Memory Add ressability	64K	64K	1MB	1MB	1MB	1MB	16M	4GB
Virtual Memory	NO	NO	NO	NO	NO	NO	1GB/task	64TB
On Chip (Management)	NO	NO	NO	NO	NO	NO	YES	YES
I/OAddressability	256B	256B	64KB	64KB	64KB	64KB	64KB	4GB
Add. Modes	5	5	24	24	24	24	24	7
Co-proce.Interface	NO	NO	YES	YES	YES	YES	YES	YES
REGISTER Arithmet	1	1	8	8	8	8	8	8
Index	0	0	4	4	4	4	4	-
Segment	0	0	4	4	4	4	4	6
GRPs	6	6	8	8	8	8	8	8
Code compatability		8080code			8086 code			

It has a 32 bit address bus and a 64 bit data bus. Some of the features are Superscalar architecture (more than one execution unit),on-chip cache memory for data and code, Branch prediction, high performance floating point unit, Performance monitoring.

Overview of Intel Pro-pentium

The two biggest players in the PC CPU market are Intel and Motorola. Intel has enjoyed tremendous success with its processors since the early 1980s. Most PCs are controlled by Intel processors. The primary exception to this rule is the Macintosh. All Macs use chips made by Motorola. In addition, there are several firms, such as AMD and Cyrix, that make processors which mimic the functionality of Intel's chips. There are also several other chip manufacturers for workstation PC's.

The Intel Processors

The Intel Corporation is the largest manufacturer of microchips in the world, in addition to being the leading provider of chips for PCs. In fact, Intel invented the microprocessor, the so-called "computer on a chip," in 1971 with the 4004 model It was this invention that led to the first microcomputers that began appearing in 1975. However, Intel's success in this market was not guaranteed until 198l, when IBM released the first IBM PC, which was based on the Intel 8088. Since then all IBM machines and the compatibles based on IBM's design have been created around Intel's chips. A list of those chips, along with their basic specifications, is shown in Table 1.4. Although the 80>SS was the first chip to be used in an IBM PC IBM actually used an earlier chip, the 808(1, in a subsequent model, called the IBM PC XT.

The chips that came later—the 286, 386, 486, and even the Pentium-I—correspond
To certain design standards that were established by the 8086. this line of chips often referred to as the 80´86 line.

The steady rise in bus size, register size, and addressable memory illustrated in Table 1.4 has also been accompanied by increases in clock speed. For example, the clock attached to the first PCs ran at 4.77 MHz.

Whereas clock speeds for Pentium chips started at 60 MHz. In 1993 and quickly rise to 100, 120, and 133,150, and 166 MHz.

Table 1.4: Intel Chips and their Specifications

MODEL	YEAR INTRODUCED	DATA BUS CAPACITY	REGISTER SIZE	ADDRESSABLE MEMORY
8086	1978	16 bit	16 bit	1 MB
8088	1979	8 bit	16 bit	1 MB
80286	1982	16 bit	16 bit	16 MB
80386	1985	32 bit	32 bit	4 GB
80486	1989	32 bit	32 bit	4 GB
Pentium	1993	64 bit	32 bit	4 GB
Pentium Pro	1995	64 bit	32 bit	64 GB

It is important to realize that these statistics do not convey all the improvements that have been made.

The basic design of each chip, known as the architecture, has grown steadily in sophistication and complexity. For example, the architecture of the 386 contained 320,000 transistors, ANCI the 486 contained 1.2 million. With the Pentium, that number grew to more than 3.1 million, and the Pentium Pro's

architecture brought the total number of transistors on tile chip to 5.5 million. The growing complexity of the architecture allowed Intel to incorporate some sophisticated techniques for processing. One major improvement that came with the 386 is called virtual 8086 mode. In this mode, a single 386 chip could achieve the processing power of 16 separate 8086 chips each running a separate copy of the operating system. It’s like capability for virtual 8086 mode enabled a single 386 chip to run different programs at the same time, a technique known as multitasking. All the chips that succeeded the 386 have had the capacity for multitasking.

The 486

Introduced in 1989 the 80486 did not feature any radically new processor technology. Instead, it combined a 386 processor, a math coprocessor, and a cache memory controller on a single chip.

Because these chips were no longer separate, they no longer had to communicate through the bus—which increased the speed of the system dramatically.

The Pentium

The next member of the Intel family of microprocessors was the Pentium, introduced In 1993. With the Pentium, Intel broke its tradition of numeric model names—partly to prevent other chip manufactures from using similar numeric names, which implied that their products were functionally identical to Intel's chips.

The Pentium, however, is still considered part of the 80x86 series.

The Pentium chip itself represented another leap forward for microprocessors. The speed and power of the Pentium dwarfed all of its predecessors in the Intel line. What this means in practical terms is that the Pentium runs application programs approximately five times faster than a 486 at the same clock speed. Part of the Pentium's speed comes from a super-scalar architecture, which allows the chip to process more than one instruction in a single clock cycle.

The Pentium Pro

Introduced in 1995, the Pentium Pro reflected still more design breakthroughs. The Pentium Pro can process three instructions in a single clock cycle—one more than the Pentium. In addition, the Pentium Pro can achieve faster clock speeds—the earliest model available was packaged with a 133 MHz clock. Intel coined the phrase "dynamic execution" to describe the specific innovation that distinguishes the Pentium Pro. Dynamic execution refers to the chip's ability to execute program instructions in the most efficient manner, not necessarily in the order in which they were written. This out-of-order execution means that instructions that cannot be executed immediately are put aside, while the Pentium Pro begins processing other instructions. This is in contrast to the original Pentium chip that can stall because it executes instructions in strict sequence.

Motorola 68000 Series

68000 microprocessor is a 16 bit processor with an addressing space of 65536 locations, each of which holds a 64-bits word; In order to address those locations, 16-bits operands are needed, two of which leave 32 bits free for other purposes; of these 32 bits, 16 are used to hold the opcode.

68000 Architecture has Instructions

- To move or manipulate a block of many locations at one time
- Instructions that perform tasks that are typical of an operating system.

68000 has a total of 47 mnemonic codes, 25 of which denote “ordinary” instructions, 14 denote instructions that perform tasks typical of an operating system, while the last 8 are instructions acting on blocks of words.

There are 13 essentially different addressing modes, further subdivided into 18 varieties; in particular, there are modes to address a special area of the memory array

Subroutines were added in view of the needs of complex programs, and a set of powerful instructions for consistent management of relative addressing was developed.

DEC

A powerful new Alpha 64 bit RISC computer chip was introduced in 1977, as new VAX (Virtual Address Extension) Computer. The VAX was a 32 bit based computer line based on operating system, called VMS.

This new computer system was more powerful and had better time-sharing capabilities than past DEC systems DECnet networking technology-enabled customers to connect different types of DEC computers together from small workstations to large corporate servers.

As the 80s drew to a close DECs were not IBM compatible and were designed as a way for users to connect to DEC server systems rather than stand-alone products. In addition, DEC manufactured all the components for its PCs, resulting in systems that were much more expensive than other PC vendors.

From 1984 to 1988 DEC developing its own RISC chip, the PRISM. Using these chips, DEC introduced a UNIX workstation running on its own UNIX, Ultrix

The RISC chips to be used in these new VAXes was a new 64 Bit chip, designed by DEC, code-named the Alpha.

The Alpha

The development of the Alpha chip began in 1988 The new chip used 64 bit technology, allowed users to pack more complexity into their programs than existing 32 Bit technology chips. In addition, though designed to replace the VAX chip, the Alpha chip would have the capacity to support a variety of different operating systems, such as UNIX and Microsoft.
But the design forced all current VAX software to be rewritten to run on the new chip. If DEC wanted other operating systems, such a UNIX or Windows NT, to run on the chip, new versions of the operating systems
would have to be developed specifically for the Alpha chip. The software would have to be specially tuned for the chips 64 Bit speed, which was a drawback.

PowerPC

A PowerPC is a microprocessor designed to meet a standard, which was jointly designed by Motorola, IBM, Apple. The PowerPC standard specifies a common instruction set architecture (ISA), allowing anyone to design and fabricate PowerPC processors, which will run the same code. The PowerPC architecture is based on the IBM POWER architecture used in IBM's RS/6000 workstations. Currently IBM and Motorola are working on PowerPC chips.
The PowerPC architecture specifies both 32 bit and 64 bit data paths. Early implementations will be 32 bit, future higher performance implementation will be 64 bit. A PowerPC has 32 general purpose (integer) registers (32- or 64 bit) and 32 floating point (IEEE standard 64 bit) registers.

Application

For military and aerospace: weapons and communications systems, more than 150 programs have chosen
PowerPC.
For industrial applications: industrial and processing control, transportation, and telecommunications.

RISC / CISC Architecture

An important aspect of computer architecture is the design of the instruction set for the processor. The instruction set chosen for a particular computer determine the way that machine language programs are constructed. Early computers had small and simple instruction sets, forced mainly by the need to minimize the hardware used to implement them. As digital hardware became cheaper with the advent of integrated circuits, computer instructions tended to increase both in number and complexity. Many computers have instruction sets that include more than hundred and sometimes even more than 200 instructions. These computers also employ a variety of data types and a large number of addressing modes. The trend for computer hardware complexity was influenced by various factors, such as upgrading existing models to provide more customer applications, adding instructions that facilitate the translation from high-level language into machine language programs and striving to develop machines that move functions from software implementation into hardware implementation. A computer with a large number of instructions is classified as a Complex Instruction Set Computer, abbreviated CISC.

In the early 1980s, a number of computer designers recommended that computers use fewer instructions with simple constructs so they can be executed much faster within the CPU without having to use memory as often. This type of computer is classified as a Reduced Instruction Set Computer or RISC.

CISC Characteristics

The design of an instruction set for a computer must take into consideration not only machine language constraints, but also the requirements imposed on the use of high-level programming languages. The translation from high-level to machine language programs is done by means of a compiler program. One reason for the trend to provide a complex instruction set is the desire to simplify the compilation and improve the overall computer performance. The task of a compiler is to generate a sequence of machine instructions for each high-level language statement. The task is simplified if there are machine instructions that implement the statements directly. The essential goal of a CISC architecture is to attempt to provide a single machine instruction for each statement that is written in a high-level language. Examples of CISC architectures are the Digital Equipment Corporation VAX computer and the IBM 370 computer.

The major characteristics of CISC architecture are:

1. A large number of instructions-typically from 100 to 250 instructions
2. Some instructions that perform specialized tasks and are used infrequently
3. A large variety of addressing modes-typically from 5 to 20 different modes

4. Variable-length instruction formats

5. Instructions that manipulate operands in memory

RISC Characteristics

The concept of RISC architecture involves an attempt to reduce execution time by simplifying the instruction set of the computer. The major characteristics of a RISC processor are:

1. Relatively few instructions
2. Relatively few addressing modes
3. Memory access limited to load and store instructions
4. All operations done within the registers of the CPU
5. Fixed-length, easily decoded instruction format
6. Single-cycle instruction execution
7. Hardwired rather than microprogrammed control

A characteristic of RISC processors is their ability to execute one instruction per clock cycle. This is done by overlapping the fetch, decode and execute phases of two or three instructions by using a procedure referred to as pipelining. A load or store instruction may require two clock cycles because access to memory takes more register operations. Efficient pipelining, as well as a few other characteristics, are sometimes attributed to RISC, although they may exist in non-RISC architectures as well. Other characteristics attributed to RISC architecture are:

1. A relatively large number of registers in the processor unit
2. Use of overlapped register windows to speed-up procedure call and return
3. Efficient instruction pipeline
4. Compiler support for efficient translation of high-level language programs into machine language

programs.

Summary

- Microprocessor acts as a CPU in a microcomputer. It is present as a single IC chip in a microcomputer. Microprocessor is the heart of the machine.
- A MICROPROCESSOR is a multipurpose programmable logic device that reads binary instructions from a storage device called memory accepts binary data as input and processes data according to those instructions and provides results as input.

- The single chip 3rd generation microprocessor having 64-pins started with the introduction of 16-bit Intel 8086 in the year 1978.
- The Intel 8080, an 8-bit microprocessor, of nMOS technology was developed in the year 1974 which required only two additional devices to design a functional CPU.
- The single chip 32-bit microprocessor was introduced in the year 1981 by Intel as iAPX 432
- The Intel Corporation is the largest manufacturer of microchips in the world, in addition to being the leading provider of chips for PCs.
- Introduced in 1989 the 80486 did not feature any radically new processor technology.
- 68000 microprocessor is a 16 bit processor with an addressing space of 65536 locations, each of which holds a 64-bits word;
- An important aspect of computer architecture is the design of the instruction set for the processor. The instruction set chosen for a particular computer determines the way that machine language programs are constructed.