Unit 1 The CPU

Structure:

1.1 Introduction

In order to know the meaning of CPU or the way to troubleshoot it. You must know the physical and mechanical concepts of PC. PC or personal computer is a small digital device made out of Microprocessor chip and designed especially for the use of individual person. PC is not a single device. It is the combination of different components and devices. Before we start troubleshooting a PC we must understand these different devices.

In this unit you will study one of those devices in detail and learn how to troubleshoot. You may feel amused to read the word troubleshooting without knowing the meaning of it. Troubleshooting is way of detecting the problem in the PC or the cause of the problem and fixing the problem so that the PC can function according to needs of the user. This problem may be from any of the components of the PC. Since all these components are interrelated the failure in one device may cause the whole system stop working or work haphazard. Troubleshooting is a technique to solve this problem and make the system work appropriate. The different components of PC are CPU, motherboard, memory, hard drives, monitor, ports, adapter USB, etc. which you will be studying one by one in later units. In this unit you will learn how to trouble shoot the CPU which is an essential part of a computer. In fact, it functions as a brain to the system. We often consider CPU to be a synonym for cabinet. However, you should keep in mind that there is a vast difference between the two. The CPU is the controller while the cabinet is a component that holds CPU and memory along with BUSes for data flow. Integrated circuit technology has realized the importance of Central Processing Unit (Processor) as it is expected to perform three major functions. They are mathematical calculations, logical comparisons, and data manipulation. Though the concept of central processing is not new, it was only after the integration of central processing functions on to a single silicon chip, that it became well known as CPU. In the mid-1970s, this single silicon chip referred to as microprocessor chip, was instrumental in enhancing the speed and performance of the computer greatly.

In order to become an effective *tekkie* (techie) you should know the essential components of CPU. You should also know the important specifications of CPU and its features. This unit will not only give you an insight into the evolution of CPU and its capabilities but also help you to learn how to solve the problems that reside in microprocessor operations.

Objectives:

After studying this unit, you should be able to:

- Identify the essentials of CPU
- Find out the different concepts of modern CPU
- Categorize and describe in detail the Intel CPUs
- Explain CPU overclocking
- Perform overclocking of the different Processors

1.2 CPU Essentials

The basic requirements for any CPU are BUSes and Processor modes. A typical diagram of a processor is shown in Figure 1.1

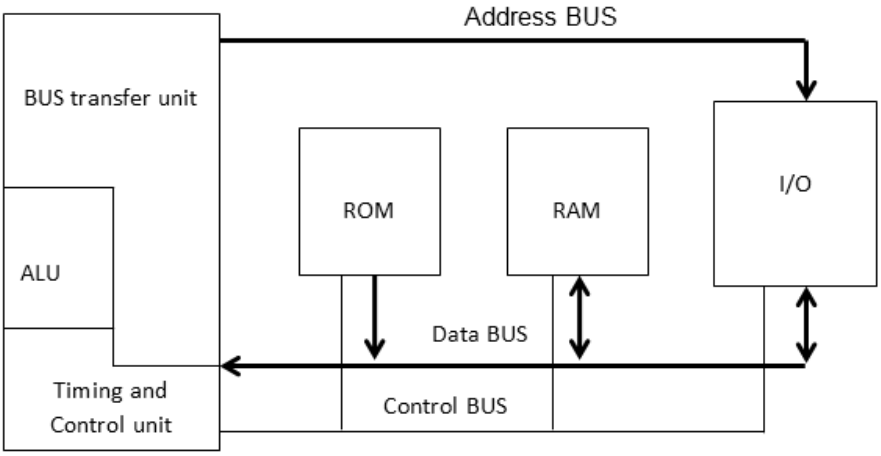

Figure 1.1: Block Diagram of CPU

1.2.1 The BUSes:

Usually the BUS is the common means for sharing data and this data transfer is done between all the devices connected to it. The BUSes are also called processor signals. The several sets of these signals are divided into three main sets, mainly:

- **The Data BUS:** This BUS is responsible for the to and fro movement of information in the CPU. It acts as a measure of CPU performance. It is also used to carry data in and out of the CPU at any given time. As shown in figure 1.1 the data BUS is used to carry the information from CPU to RAM, ROM and I/O units as well as among Timing and control, BUS interface and ALU. The data lines are usually represented by “D” prefix (D0, D1, D2, and D3 … Dn).

- **The Address BUS:** This BUS is used to define address in the CPU. It is also called as memory BUS. The Address BUS does not carry the actual data but carries the specific address of that particular data. The address BUS measures the data in terms of address lines. For example, the CPU with address lines= 10 may have address 2^{10} = 1024 bytes. The "A" prefix (A0, A1, A2, A3 … An). is generally used to represent address lines.
- **The Control BUS:** This BUS is also called as timing and control BUS. It is used to control and coordinate the CPU operations. The various signals are read, write, interrupt, and acknowledge; parity checking, cache operation and power control and management.

Table 1.1: Difference between the three BUSes

Data BUS	Address BUS	Control BUS
Transmits instructions to the CPU from memory for execution.	Transmits address to memory before any instructions or data can be written.	Transmits number of individual signals that is used to control and coordinate the operations
Carries data or operands	Carries addresses or locations	Carries individual signals

1.2.2 Processor Modes

Before we proceed to the CPU concepts and its architecture, it would help you to have a brief introduction to some of the concepts of processor modes. In generic term, mode is a way that creates a system for itself for its processor creation and operations. Processor mode is responsible for managing and controlling the system memory and its use. Processor modes are classified into three types as:

- **Real Mode:** This mode operates CPU in a limited environment. The real mode has the advantage of accessing speed. It is compatible with Intel 8088 chip. All processors can support real mode. Computers normally boot up in real mode or DOS mode.

- **Protected Mode**: This mode used in modern multitasking operating systems was first implemented in 80826. Protected Mode has several advantages.
    - It offers faster access to memory

- It supports multitasking facility that manages the operating
- System in the execution of many programs at a time.
- There is no limit for accessing the memory.
- It allows the computer to use additional memory whenever
- Needed along with the support of virtual memory.

- **Virtual Real Mode:** This mode of operation is the enhancement of protected mode. Protected mode is used to run graphical multitasking OS like windows. If you want to run DOS program in the windows system then you would have to use the virtual real mode. This is because the necessity of running DOS program on real mode and not in protected mode has given rise to the virtual real mode. This mode will simulate the real mode to start in the protected mode and help in running DOS programs in windows. The virtual machine will have separate address space dedicated to it, which helps in invoking this feature of operating virtual real mode machines.

Self Assessment Questions

1. _____ BUS is used to control and coordinate the CPU Operations.
2. _____ Mode is used in multi-tasking machines.
3. Control BUS is also called as _____ BUS.

1.3 Modern CPU concepts

In order to understand the full concept of the CPU you would have to draw up a very big outline, which is beyond the scope of this book. However, there are certain concepts, which are basic and essential to understanding the PC growing world.

1.3.1 CISC vs RISC CPUs:

CISC (pronounced 'sisk') is the acronym for **C**omplex **I**nstruction **S**et **C**omputer. Most computers use CISC because hardware is always faster than software and an instruction set is made that is powerful and helps the programmers to use assembly level instructions with less coding. RISC on the other hand is based on the philosophy that almost no one uses complex assembly language instructions, and people mostly use compilers, which never use complex instructions. RISC (pronounced 'risk') is the acronym for **R**educed **I**nstructions **S**et **C**omputer. RISCs are mostly used in high-end workstations.

Table 1.2: comparisons of CISC and RISC CPUs

CISC	RISC
CISC chips are relatively slow	RISC chips are comparably faster
Use less instructions	Comparatively use more instructions
Use large and complex instructions	Use fewer, simpler and faster instructions
Comparatively costlier	Cheaper
Use many new transistors	Use fewer transistors
Versatile processing	Less versatile
Low performance due to the use of more number of transistors	Faster CPU performance

1.3.2 Circuit size and Die size: Circuit size is like scaling the processor model or drawing the miniature of the processor. In order to make powerful processors more transistors, which are smaller, are required. Therefore, circuit size is made smaller with the help of integrated circuit fabrications. The maximum shrinking can be done up to 1 micron but the recent processors can use even as less as 0.18 micron circuit size.

The Die size is the physical surface area, which means the area of the chip and measure in square millimeters (mm^2). It is the term used for wafer made out of silicon. Smaller the size of the wafer the closer the component arranges which increases performance. Smaller die size will also help in getting more chips on single wafer and reduce the manufacturing cost and also relatively reduce power consumption.

1.3.3 Processor Speed:

The processor speed depends upon different factors like, circuit size, die size, processor type, type of chip used, instructions set, etc. On observation you will find that all these factors are interlinked to one another.

- Essentially the processor design has its effective role in which it has to specify the internal time requirements that the maximum limit does not exceed the speed, which the chip can handle.
- You will find that the manufacturing factors like circuit size and die size as mentioned above will have its influence on the speed.
- Smaller the chips faster will be the processing speed due to shorter signals flow and less power consumption.

- Heat is also an important factor that affects speed. As the chips get over heated, it locks itself, thus slowing down the processor.
- Due to some manufacturing differences, the quality of the process varies even after the product is manufactured in the same process.

1.3.4 Processor Cooling:

Each of the millions of transistors liberates small amount of heat every time they are switched on or off. The heat thus generated will give rise to many serious problems in the processor like system crash, unexpected rebooting, lockups etc. This sometimes results in memory errors, application errors, disk errors etc. Although repeated overheating of processor may rarely result in permanent damage, it is difficult to identify these kinds of problems.

These days processor cooling has become a major concern for computer hardware manufacturers. Unlike earlier processors, nowadays processors use more numbers of transistors which liberate tremendous amount of heat. Therefore to cool the processors special cooling methods have to be adopted the processors are usually cooled by active heat sinks. An active heat sink is made up of fans which are mounted on a metal sink with the help of fins. However, the problem with an active sink is that when the fans stop working then the heat generated by processor will be very high. Therefore tachometers are integrated into it to raise an alarm in case of accident due to heat damage. This warning will help in addressing fan failure issue immediately.

1.3.5 System Clocks:

A system clock is used to drive the circuits in the PC. The smallest unit of time in which the processing takes place is known as one cycle. The unit to measure it in terms of frequency is MHz. In older PCs there used to be only one system clock to drive the processing. However, modern PCs use many such clocks (may be four or five) for processing; each of them running at different speeds. System clock is referred to the speed of the memory BUS running on the motherboard.

In order to generate the system clock, a single clock generator circuit is used to create different clocks and then various clock multiplier or divider circuits will create the clock signals for these clocks.

Table 1.3 gives you the detailed arrangement in clocks in 266 MHz Pentium II PC and the relationship that exists between them.

Table 1.3

Device/BUS clock	Speed (MHz)	Generated as
Processor	266	System Clock * 4
Level 2 Cache	133	System Clock * 2 (or Processor / 2)
System (Memory) BUS	66	1 system clock
PCI BUS	33	System Clock / 2
ISA BUS	8.3	PCI BUS / 4

The entire system speed relates to the speed of the clock system. This is why it is very important to increase the speed of the system clock rather than the speed of the processor. This is because whatever the speed of the processor it has to sit idle until the completion of the other slower part of the system.

1.3.6 Architectural Performance Features: Each time you boot the system you assume that the system performance improves. Hence, research on this feature continues with the designer trying to find ways to enhance performance. The different features of performance enhancement are as follows:

- **Superscalar Architecture:** This architecture implements a base for parallel computing. This is the measure of the number of operations executed in a computer simultaneously. This is called *Instruction level parallelism*. The main capability of CPU is to allow multiple executions. This helps CPU to process many instructions simultaneously with every clock cycle. This is super scalar architecture. For example, the Pentium pre-processor uses two execution pipelines at the same time; this is multiprocessing within the CPU itself.
- **Pipelining:** Pipelining a technique to construct faster CPUs. Using pipelining you can execute more than one operation at a time. When one instruction is already in execution state, the pipelining allows another instruction to start execution while the first instruction is still being executed. This helps in working out many instructions in the same clock cycle. In this way, CPU uses its resources in a better way rather than sitting idle. Some instructions may take 2-3 clock cycles to complete the execution and while some complex instructions may take

6-7 clock cycles to complete its execution. Therefore pipelining helps in using the resources, though the CPU can only finish one instruction /clock cycle.

- **Super Pipelining:** Super Pipelining is similar to normal pipelining but with series of operations are unblocked so that as many instructions execute at a single clock time. This is an enhancement over the earlier simple pipelining. As you are aware a CPU works on pipelining concepts. If we make the pipelines longer which is nothing but increasing the number of stages, then each step will perform less work so that the processor can be scaled to high frequency. This is super pipelining.
- **Speculative Execution and Branch Prediction:** Speculative execution and branch prediction is used to give the probable prediction on branching the instruction in the CPU. The basic difficulty in pipelining of CPU lies in branches. For example, when we use branches in the conditions, the sequence of the program execution also changes or jumps form one level to another at any given time. This challenges the pipelining as it is not linear. Though the CPUs have the ability to execute multiple instructions at a time however, due to this branching it cannot be maintained always. CPU must be able to jump speculatively to the next instruction when the branches come in the instruction. This can be achieved by predicting the branches. Examples of branches may be "if/then" statements.
- **Dynamic Execution:** Dynamic Execution is a collection of different techniques for predicting the nested or multiple branches. The performance of the CPU also depends on the kind of program written for the instructions. Sometimes system software assembly and the linking process may disturb the best program code. Therefore, the dynamic execution helps the CPU to order the levels of the instruction execution according to the branches and helps in improving the performance.
- **Register Renaming and Write Buffers:** When the multiple executions take place there should not be any kind of confusion in program execution. This is taken care of by register renaming by differentiating the registers. This helps in avoiding the pipeline overloading or jam. When the instruction is executed, the result needs to be stored

someplace until they can be stored in the memory locations. Write buffers do this. Several buffers help in the execution of various instructions and avoid the jam or stalling of pipeline.

- **Multiprocessing:** This is the technique of running more than one processor in a system. Increasing the number of processors will double the system performance. The increasing of system performance is directly proportionate to the increase in the number of processors. The following are the basic requirements for multiprocessing :
  1. The host computer must have the motherboard support to Handle the multiple processors.
  2. The host computer should use the processor that suits the Multiprocessing
  3. The host computer should use the operating system that Suits multiprocessing like windows, NT/2000 or LINUX.
- **Multimedia Extensions:** The multimedia extension is an add-on to CPU performance. For technocrats, knowledge alone is not sufficient for success in their work. They also depend on making effective presentations by taking the help of graphics, animations etc. It was in late 90s that Intel added 57 new instructions that support graphics with the MMX extensions using the technique called Single instruction Multiple Data (SIMD). Later AMD and SSE added a few more instructions to introduce 3DNow. SSE-II used streaming SIMD extensions, which supported audio and video graphics, and speech recognition.

Self Assessment Questions

4. RISC chips have faster CPU performance than CISC. (True or False)
5. _____ is a technique of running more than one process in a system.
6. MMX is an extension that supports _____ applications.

1.4 Processors

If you observe the evolution of the CPUs, you will realize that the change from one generation to the other is not one of just average development but rather a tremendous change in technology with more emphasis on greater performance, execution, efficiency, raw speed, and data through input and

design enhancements. This section will help you understand the panorama of the Intel microprocessors' evolution and also aid you in comparing their current characteristics.

1.4.1 Intel 8088/8086

This was introduced during 1978-1979. The microprocessors 8088 and 8086 are similar except that 8088 uses 8 bit BUS and 8086 uses 16-bit BUS for data transfers. Though 8086 was the first processor, it did not become popular because by the time it was launched, 80286 was introduced.

Table 1.4: Categories of processors

Table 1.4 (a) General Information

Manufacturer	Intel
Family Name	8086
Processor Generation	First
Motherboard Generation	First
Introduced in	June 1978
Versions	8086 / 8086-8 / 8086-10

Table 1.4 (b) Speed Specifications

Memory BUS speed (MHz)	4.77 / 8 / 10
Processor clock multiplier	1.0
Processor speed (MHz)	Same as memory BUS speed

Table 1.4 (c) Benchmarks

Norton SI	1? /1? /1?

Table 1.4 (d) Physical Characteristics

Process Technology	NMOS, CMOS
Circuit size (microns)	3.0
Die Size (mm^2)	33
Transistors (millions)	0.029

Table 1.4 (e) Voltage Power and Cooling

External or I/O Voltage (V)	5
Internal or Core Voltage (V)	5
Power Management	None
Cooling Requirements	None

Table 1.4 (f) Packaging

Packaging style	40-Pin DIP
Motherboard Interface	DIP socket.

Table 1.4 (g) External Architecture

Data BUS width (bits)	16
Maximum Data BUS Bandwidth (Mbytes/sec)	9.1/15.3/19.1
Address BUS Width (bits)	20
Maximum Addressable Memory	1 MB
Level 2 Cache Type	None
Multiprocessing	No

Table 1.4 (h) Internal Architecture

Instruction set	8088
MMX support	No
Processor Modes	Real
X86 execution method	

Table 1.4 (i) Internal Components

Register size (bits)	16
Pipeline depth(stages)	1
Level 1 cache size	None
Integer units	1
Floating point unit/ math processor	Optional 8087 co-processor
Instruction decoders	1
Branch prediction buffer size/accuracy	None
Write buffers	None
Performance enhancing features	None

1.4.2 Intel 80386

This chip gives the processor capability of GUI-based operating system such as Microsoft windows. It used pipelining process and high clock frequencies to increase performance. The processor used standard x86 instruction set from the time it was introduced.

The tables below give details of the processor.

Table 1.5

Table 1.5 (a) General Information

Manufacturer	Intel/ Intel, AMD, Cyrix/ AMD, Cyrix
Family Name	80386DX
Processor Generation	Third
Motherboard Generation	Third
Versions	80386DX-16/80386DX-20/ 80386DX-25/ 80386DX-33/ 80386DX-40
Introduced in	Oct. 1985/Feb. 1987/April 1988/April 1989/1?

Table 1.5 (b) Speed Specifications

Memory BUS speed (MHz)	16/20/25/33/40
Processor clock multiplier	1.0
Processor speed (MHz)	Same as memory BUS speed

Table 1.5 (c) Benchmarks

Norton SI	~15/~20/~25/35/~43

Table 1.5 (d) Physical Characteristics

Process Technology	CMOS
Circuit size (microns)	originally 1.5, now 1.0
Die Size (mm^2)	1?
Transistors (millions)	0.275

Table 1.5 (e) Voltage Power and Cooling

External or I/O Voltage (V)	5
Internal or Core Voltage (V)	5
Power Management	None
Cooling Requirements	None

Table 1.5 (f) Packaging

Packaging style	132-Pin PGA
Motherboard Interface	132-Pin Socket

Table 1.5 (g) External Architecture

Data BUS width (bits)	32
Maximum Data BUS Bandwidth (Mbytes/sec)	63.6/76.3/95.4/127.2/152.6
Address BUS Width (bits)	32
Maximum Addressable Memory	4 GB
Level 2 Cache Type	None
Multiprocessing	No

Table 1.5 (h) Internal Architecture

Instruction set	x86
MMX support	No
Processor Modes	Real, Protected, virtual real
X86 execution method	Native

Table 1.5 (i) Internal Components

Register size (bits)	32
Pipeline depth(stages)	4
Level 1 cache size	None
Integer units	1
Floating point unit/ math processor	Optional 80387 co-processor
Instruction decoders	1
Branch prediction buffer size/accuracy	None
Write buffers	None
Performance enhancing features	None

1.4.3 Intel Pentium P5

With the generation of 586 processors, Intel intended to establish its trademark in the market due to the development of AMD and Cyrix machines. The Pentium is available in a number of speeds. Pentiums come in two versions such as regular and overdrive. Pentiums use three different

sockets. The original Pentium 60 and 66 use Socket 4 while Pentiums from 75 to 133 fit in either socket 5 or socket 7. Pentium 150s, 166s and 200s require Socket 7. Intel makes Pentium Overdrives that allow the use of faster Pentiums in older Pentium sockets (in addition to Overdrives that go in 486 motherboards). Pentium has the following features

- It is the first superscalar processor. It uses two parallel execution units and helps in pairing with 80486 series on the single chip so that it can make the processor more accurate. This is partial super scalar since the second instruction cannot complete its execution before the first one. It is sometimes referred as the Pentium optimization.
- Most of the Pentiums run on faster memory BUS. This greatly improves performance. Pentium motherboards also incorporate other performance- enhancing features, such as pipelined burst cache.
- Pentium provides Wider Data BUS by doubling the data BUS to 64 bits and doubling the bandwidth that manages the to and fro movement of data from the memory.
- The Pentium uses a split-level 1 cache, 8KB each for data and instructions. The cache is split so that the data and instruction caches can be individually tuned for their specific use.
- When branches are encountered the Pentium uses branch prediction to prevent pipeline stalls.
- All Pentiums have built in SMM power management.
- The floating-point unit of the Pentium is improved so that it is faster than that of the 80486.

Overdrive processors have settings and features that make it useful in older machines. They are:

- Integrated voltage regulators are added whenever there is need so that they can work in the voltage of the socket they are intended to work with.
- They have the right pin configuration for the socket.
- They are hard-wired to a specific clock multiplier; they do not set their multiplier based on motherboard jumpers as regular Pentiums do. This saves the user from worrying about what jumpers to change when replacing the processor.

1.4.4 Intel Pentium with MMX Technology

MMX sometimes stands for Multimedia Extensions or Matrix Math Extensions. The main purpose of this extension is to provide hardware support for the Multimedia applications. The following are the important features of MMX extensions:

- It has got twice the primary cache comparative to earlier processor. It has got 16 KB each for level 1 data and instruction caches.
- Cache mapping is improved here with the 4-way set associative.
- The pipeline features increases the executions levels to 6 stages.
- It helps in optimal use of pipelines by running the instructions in a two executing pipes.
- Due to the branch prediction device the accuracy is improved.
- Efficient in the instruction decoder.

This too has overdrive technology that has the above specified changes.

1.4.5 Intel Pentium Pro (P6 machine)

This is the successor of Pentium processor. The performance achievement is approximately 50% higher than a Pentium of the same clock speed. The following are the technical enhancements along with the other features mentioned in the earlier generation processors:

- **Super Pipelining:** The Pentium Pro dramatically increases the number of execution steps to 14, from the Pentium's 5.
- **This introduces Integrated Level 2 Cache** compared to all earlier processors; achieves more performance instead of motherboard based cache.
- The Pentium Pro is optimized for running 32-bit code and so gives a greater performance improvement over the Pentium when using the latest software.
- The address BUS on the Pentium Pro is widened to 36 bits, giving it a maximum addressability of 64 GB of memory.
- Quad processor configurations are supported with the Pentium Pro compared to only dual with the Pentium.
- Instructions flowing down the execution pipelines can complete out of order.

- **Superior Branch Prediction Unit helps in the branch target buffer to** double the size of the Pentium's and its accuracy is increased.
- **Register Renaming:** This feature improves parallel performance of the pipelines.
- **Speculative Execution:** The Pro uses speculative execution to reduce pipeline stall time in its RISC core.

1.4.6 Intel Pentium II

PC community has confirmed to adopt Pro processors and MMX technology. Later Intel tried combining both the features and the result is found in 1997 which they named it Pentium II. Therefore Pentium II consists of 32 bit operating system and software. It also has new instructions which are necessary to handle media with the help of MMX technology. Pentium II is capable of performing 2 times better than 200 MHz Pentium processor. This has the evolutionary effect in performance over Pro with the following features abiding in it.

- **Doubled Level 1 Cache:** level 1 cache is increased in size, from 16 KB to 32 KB total (16 KB + 16 KB).
- **Segment Register Caches:** These special caches are used to help the Pentium II process 16-bit code somewhat more efficiently. The Pentium Pro was optimized for 32-bit processing, meaning that it did not deal with 16-bit code quite as well.
- **Deeper Write Buffers:** The write buffers were increased in size, producing a small performance improvement.

1.4.7 Intel Core 2

This has the ability to handle the 64 bit data transfer in a multicore processor. The following are the features of Core 2 processors.

- The processors speed ranges from 1 GHz to 3 GHz.
- They have Level 2 cache of 2 MB or 4MB.

Intel Core 2 has three versions of itself. They are *Core 2 solo, Core 2 Duo, Core 2 Quad.Core 2 Solo* could handle the single core processor. *Core 2 Duo* can handle dual core processors on a single chip, and *Core 2 quad* can handle two chips and each chip consists of 2 Core. Therefore in a package of 4 Core was arranged in a multi-chip module.

1.4.8 Intel Atom

As we grow in technology the size kept on decreasing with increase in power and performance. Therefore in order to serve the netbooks purposes Intel created *Atom.* Netbook is a smaller than laptop computers and generally used for accessing internet and outside use. Since they are very small the processors used need to be inevitably small so that it can fit inside the available place. The following are the features of Intel Atom. They are:

- The speed ranges from 1 GHz to 2GHz.
- Level 1 cache is increased in size to 32KB and Level 2 cache is 512KB.

Atom has been classified into two versions as *Single core* and *Dual core.*

1.4.9 AMD CPUs

Advanced Micro devices are the non-Intel chips which have become the real competitors for Intel CPUs. The industry considers them to be compatible and perfectly designed. There is a strong competition among the processors as each one is gives a better performance than the other. If AMD is better than Intel CPUs with their improved processor performance and operating speeds, Intel CPUs are better in their 3D and network parameters. Therefore, the selection of the processor hugely depends on the requirement of the application, which is being used. The AMD series incorporated write-back cache and enhanced power management features including 3-volt operations, system management mode (SMM) and clock control. The higher versions of AMD are very much compatible with all x86 operating systems and software. They also have heat sinks and fans, which are securely mounted and help in reducing the vast amount of heat generated by the processors.

Activity 1:

Consult the network administrator of your organization and find out the different processors used in it. Also, find the features and analyze the differences between them.

Self Assessment Questions

7. 8088 use _____ bit BUS while the 8086 uses _____ bit BUS for data transfer.

8. The speed specification of clock multiplier of the 8088/86 processor is _____.
9. The motherboard interface of 8088/86 packaging is _____.
10. The two types of Intel 386 are _____ & _____.
11. State whether the following statements are true or false.
    a. Pentium is the first superscalar processor.
    b. The use of speculative executive will not reduce pipeline stall time in the RISC core in sixth generation processor

1.5 CPU Overclocking

Though the CPU and microprocessor are used synonymously, in reality CPU is a part of microprocessor. Microprocessor differs from CPU in a few characteristics like instruction set, bandwidth, and clock speed. Clock speed is the measure of number of instruction sets that the microprocessor executes in one second. Speed margining is another name for overclocking. By overclocking you can make the CPU run faster than the actual speed. This increases the performance of the CPU. Therefore, overclocking is often a means to maximize the processor performance. The main reason for overclocking is to sum up the additional performance in less or no cost. For example, by increasing the BUS speed on the motherboard you can increase the speed of the computer with an Intel Pentium III processor running at 933MHz to run at speeds equivalent to a Pentium III 1050MHz processor.

In spite of having the advantage of increasing performance, overclocking, is not followed regularly.

1.5.1 Overclocking Requirements

The important elements that effect overclocking are: the CPU, the motherboard, system memory, and CPU cooling. These are some of the issues with respect to overclocking success/failure.

1 **CPU:** Intel CPUs are found to be successful in overclocking. Because AMD and Cyrix CPUs run at the closer rated limits they are very reachable to compete with Intel processors. In addition, we must be very careful with remarked and resold CPUs, which already run at high speed. They are all fake CPUs. In some of the CPUs, there are locked clock multipliers.

2 **Motherboard:** The overclocking may also fail due to the fault in motherboard. Due to the weak signals and lack of electrical signals with its BUS signals cause the system crash. The weak signals will not support the overclocked CPUs. Motherboard should also support a wide range of voltage variations in the CPU. If there is any problem in finding the voltage jumper CPU will not overclock..

3 **System Memory:** RAMs can work well with overclocking systems till the BUS speed exceeds 66MHz. You may require higher end RAMs like EDO RAM and SD RAM to handle the BUS speed above 66 MHz as the higher end of the Ram increases the performance of the overclocking supports faster.

4 **CPU Cooling:** Standard heat sinks and fans cannot cool the large amount of heat released by overclocking. . Extra cooling facility is needed to cool that amount of heat. While fitting a good sink we must take care that it fits into the CPU tightly so that there is no air gap and we must also ensure that thermal grease is applied between the CPU and heat sink.

1.5.2 Potential Pitfalls

The major pitfalls of CPU overclocking are intermittent operations, shortened life span, and outright failure.

Intermittent Operations: The heat produced by the CPU will cause noise in the signal errors, which causes system crash. This will force us to shut down the system until the CPU cools down.

Shortened life span: The excess heat produced by the CPU may sometimes also cause the shorter life span of the CPU than shutting down suddenly. Due to this, the CPU which was supposed to work for 10 years will work only for 2-5 years

Outright failure: The CPU which is designed to work from -25 to 80 degrees centigrade, if it is not cooled properly then the die time of the CPU maximizes its exceed temperature limit and causes failure. Though there are millions of transistors working, it only takes two or more failed transistors to destroy the CPU performance.

1.5.3 Overclocking the System:

You can overclock the CPU in three ways. They are overclocking the processor, overclocking the system BUS and overclocking both.

The three major steps in overclocking are change in BUS speed, change of the multiplier, and change in the voltage supply.

1. **Change the BUS speed:** The BUS speed is the speed in which the CPU communicates with the other parts of the computer. It is measured in terms of clocks. To change the BUS speed you need to do the following:
    1 Check in your motherboard manual for term like “clock speed”, “CPU External Frequency Selection”, or Front Side BUS which are called the jumpers which you may need to change.
    2 You may have to change many other jumpers so that you can create a new BUS speed.
    3 You can change the BUS speed if you have “soft menu” technology motherboard.
    4 Change the BUS speed settings in the CMOS setup menu.
    5 Increase the BUS speed step by step. You can increase only one-step at a time.
    6 Now your system is successfully over clocked.

2. Change the Multiplier: A multiplier is used to measure the ratio of internal clock rate and external supplied clock.

For example, a computer which has an external clock 156 MHz and clock multiplier of 10x will have an internal CPU clock rate of 1.56 GHz.

To change the multiplier you need to do the following:

1 Check a set of jumpers marked with the name “Clock Multiplier” in your motherboard manual.
2 There may be many jumpers, which may be needed to change the settings. You can use CMOS setup menu to change these settings if you have soft menu motherboard.

3. Change the voltage supply: In some situations you may need to increase the voltage supply to the CPU to increase the CPU performance reliably in high speed. It is always good to increase the voltage supply

when CPU is not able to run reliably in one clock speed. However, the heat produced should be taken care of by using cooling agents.

1.5.4 Overclocking the Intel Processors

Intel processors are usually considered as the easiest CPUs to overclock. Processors are usually boosted to increase the performance of the quality demands. Intel processors are feasible for increasing the performance of the CPUs. You need to overclock the Intel Pentium processors by changing BUS speed, or multiplier, or voltage supply.

Overclocking the Intel Celeron: This is one of the overclocking friendly Intel Pentium processor. The major features of Intel Celeron are that it is the Pentium Core, the price is lower and produces high quality which helps in increasing performance through overclocking. However, it has a limitation in the use of overclocking with respect to locked multiplier and a locked BUS speed of 66 MHz

Locked Multiplier lessens the processor speed setting capability for the overclocking. Overclocking depends on the motherboard characteristics in order to achieve more speed. Motherboard also support by providing additional front side BUS and capability to set voltage supply. Modern motherboards use software to set the clock multipliers, BUS speed and voltage supply unlike the older versions of motherboards which used jumpers. This helps us to change the settings without opening the case and without disconnecting the settings. The success of overclocking of Celeron also depends on the availability of voltage supply. With high voltage, it can reach faster signal speed. The motherboard remains stable at any point of time. Therefore, additional setting is given to change the Front Side BUS (FSB). FSB MHz speed can refer to either the CPU, or the memory. They are NOT always the same. A system can have a CPU FSB speed of 133, and the memory at 100. Therefore FSB needs to be increased to set the overclocking setting. In case after increasing the FSB if your system doesn't boot then you must increase the voltage. In doing this the heat may tremendously increase which requires cooling.

Pentium: The most common factor while overclocking the Pentium processors is to increase the clock multipliers. When you try doing this mostly it may not boot or system may perform in the 1/3rd of the actual

speed. Therefore, first it will try to increase the FSB. This increases the speed of PCI and AGP. These cards are built with greater tolerances.

To overclock you need to do the following

1 You need to have rights to adjust the clock multiplier, FSB, and core voltage, which depend upon the model of the processor.
2 You need to check the cooling capability of the processor if necessary you need to improve the cooling feature.

You will notice that Pentium II/III machines are not tolerant for overclocking when compared to Celeron, though you can carry out experiments by making small increments. You need to note that in order to increase the FSB speed you require to reduce the clock multiplier on your systems.

In general overclocking immediately voids any processor warranty. Adequate preparation and precautions are an absolute requirement before attempting to overclock any processor. You should have a dependable method of monitoring processor temperature, along with additional cooling resources installed on the system.

Activity 2:

Try to collect an old CPU and increase its performance through overclocking.

Self Assessment Questions

12. Which are the three major steps in overclocking?
13. Overclocking the Intel Celeron depends on _____.
14. FSB Stands for _____.

1.6 Summary

In this unit, you have studied about the different essentials of CPU. We discussed about the BUSes and processor modes. You have also identified the different concepts of modern CPU like CISC vs. RISC comparison of circuit size and die size; importance of cooling the processor, system clocks; packing the processor; and features of architectural performance. This unit has also explained the evolution of Intel CPU and different Intel processors like Intel 8088/8086, Pentium Pro processor, MMX technology, Pentium II, core 2 processor and AMD processors. Apart from this we have discussed

the description of system memory; the meaning of CPU overclocking, overclocking requirements and its potential pitfalls; how to overclock the Intel processors. With this knowledge you must be able to overclock your CPU.

1.7 Glossary

Term	Description
CISC	Stands for Complex Instruction Set Computer. CISC is used to handle many instructions in the CPU.
RISC	Stands for reduced instruction set computer. Which handle fewer instructions in the CPU?
Intel	It is the world's largest processor manufacturing corporation, which has made trademark in processor market.
MMX	Stands for multimedia extension, which is used to support multimedia application in the CPU.
Circuit size	It is the miniaturization of the processor. In order to make processor more powerful large number of transistors are used.
Die size	It is the physical surface area size on the wafer. This is measured in square millimeters.
Overclocking	It is the unusual method of running CPU @ the speed more than the actual rated to increase the performance.

1.8 Terminal Questions

1. What are the different essentials of the CPU?
2. Compare CISC with RISC CPUs.
3. List out the different features of Architectural Performance.
4. Differentiate between the various Intel Micro Processors.
5. List out the important features of MMX Technology.
6. Explain in brief the different issues in overclocking - success and failure.
7. Describe the three major steps in overclocking.
8. How will you overclock Intel Processors?

1.9 Answers

Self Assessment Questions

1. Control
2. Protected
3. Timing and control
4. True
5. Multiprocessing
6. Multimedia
7. 8,16
8. 1.0
9. DIP socket
10. DX, SX
11. a. True
    b. False
12. Change in BUS speed, Change the multiplier, Change the voltage supply.
13. Motherboard Characteristics
14. Front Side BUS

Terminal Questions

1. Refer Section 1.2: CPU essentials
2. Refer Section 1.3.1: CISC Vs RISC CPUs
3. Refer Section 1.3.6: Architectural Performance features
4. Refer Section 1.4: Intel CPUs
5. Refer Section 1.4.4: Fifth Generations Processors
6. Refer Section 1.5.1: Overclocking requirements
7. Refer Section 1.5.3:Overclocking the system
8. Refer Section 1.5.4: Overclocking the Intel Processors

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