Microprocessors and Microcontrollers
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Lecture – 07
Basic 8085 Microprocessors

So, in the computer architecture lectures we have seen the basic structure of a processor and we have seen the basic components that should be there in any processor. Now, from today onwards we will be looking into the 8085 microprocessor which is one of the, I should say the basic microprocessors that we should be familiar with to understand this whole codes of microprocessors and microcontrollers. So, we can say that for all other processors the basic idea came out from this processor design. So, that is why this makes a very good example to study any codes on microprocessors.

Of course, there are many advanced microprocessors today, but 8085 should be chosen as the base because this in the concepts they introduced there have gone a long way in manipulating the ways in which the new processors are design. So, we will first look into this processor design.

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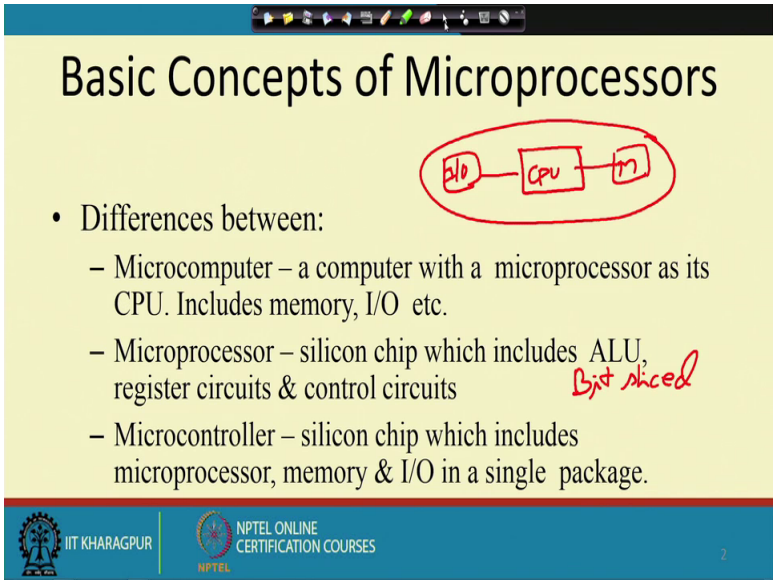

So, what is microprocessors? So, if we just try to answer this question. So, we will try to differentiate between three terms microcomputer, microprocessor and microcontroller. So, these terms are many times they come to our mind and you also see them in the

literature and we should know the difference between them very clearly. A microcomputer is a computer with a microprocessor as its CPU. So, any computer that has got a microprocessor as its central processing unit is a microcomputer.

So, it has got its own memory and input output devices that should be connected. So, to make the complete computer system we should have the additional components in it. So, as we know that for microprocessor we have for the any computer any computer system we have the basic CPU and then we have got this memory and we have got the IO devices. So, this when we talk, this CPU when the CPU is a microprocessor then we will call it a microcomputer. So, apart from that the IO devices and the memory they should be connected to make the system complete.

So, microprocessor what is it? So, it is a silicon chip which includes ALU registers circuits and control circuits. So, in our lectures on CPU design, we have seen that a CPU consists of essentially one arithmetic logic unit for doing the arithmetic logic operations, then there is a register bank to hold this intermediary values and many a times the operands are taken from these registers by the CPU by the ALU and there is a control logic which controls the overall operation.

Now, in older days these, when this computers were being designed this processor design was partitioned into designing this individual components separately. So, this separate ALU design, separate register circuits the register designs, separate control logic design so that way it made something called a bit sliced processor. So, we call it a bit sliced processor, this was called a bit sliced processor as if the design is in terms of a 4 bit ALU, 4 bit registers like that. And then we are getting the corresponding circuit done and if you need say 8 bit registered you takes two such 4 bit designs combine them to get 8 bit. Similarly if you are looking into the ALU design, basic ALU design is a 4 bit ALU, so if you want to go for higher sized ALU design. So, you have to clap this ALUs, ALU slices to get the 8 bit slice or 16 bit slice that way.

So, there it was bit slice designs, but the problem with this type of design is that you have got this separate modules and those chips are going to be separate. So, ALU is a separate chip register each register maybe a separate chip like that. And you know that when all these are integrated on a printed circuit board, so they are connected externally by means of copper lines.

So, the speed of the system is limited by this speed of this external lines, so you cannot achieve very high speed with this type of designs. So, for a high speed design, what is required is that all these components within the CPU they should be contained in a single chip. So, when we talk about microprocessor they are essentially doing that. So, all these components they are designed in a single chip. So, it is a single silicon chip which has got ALU registers and control circuitry.

Then in the later part of this course we will introduce microcontroller. So, it is actually one step ahead particularly when we are thinking about designing say embedded applications like say cell phone or say a telephone handset or say refrigerator, so that way what is a digital camera. So, what happens is that we want to go for miniaturized modules, like nobody will like a cell phone which is which is quite large in size ok. So, that way we want that to be smaller and smaller. Only the screen we want to be larger rest of the circuit they should be small.

Now how to make this small, like that in the in a printed circuit board if you put a large number of components like the processor, memory, IO, separately then that is going to take a good amount of space. So, to reduce that space requirement what is done is this entire computer is made on a single chip. So, when we are talking about these IO CPU and memory. So, they are made part of the same chips. So, they are made part of the same chip. So, when you say this, this becomes this memory IO and CPU. So, they are put into a single chip and as a result what you get is a microcontroller. So, they are very much they have become more popular when we have gone for this embedded system applications. So, they are becoming more useful.

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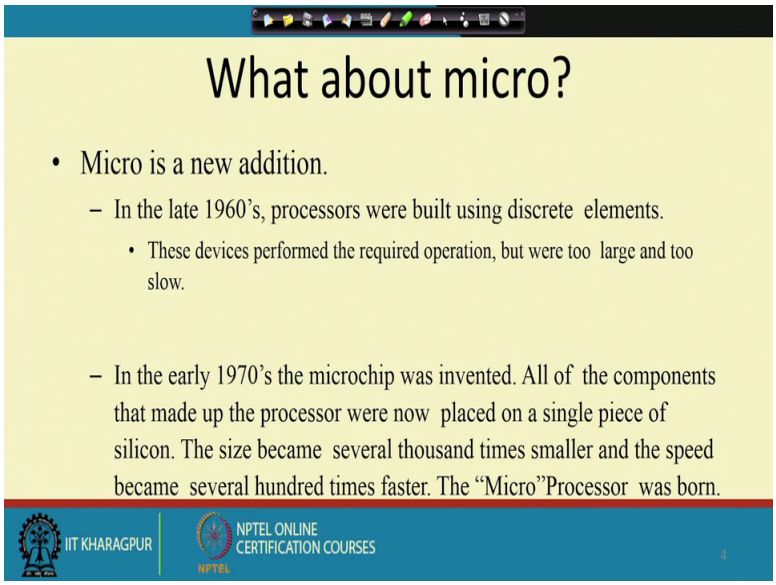

So, if we go by the definition like what about the micro, why micro why not simple processer. So, micro is a new addition, so this, the word microprocessor it comes from the combination of two words the word micro and the word processor.

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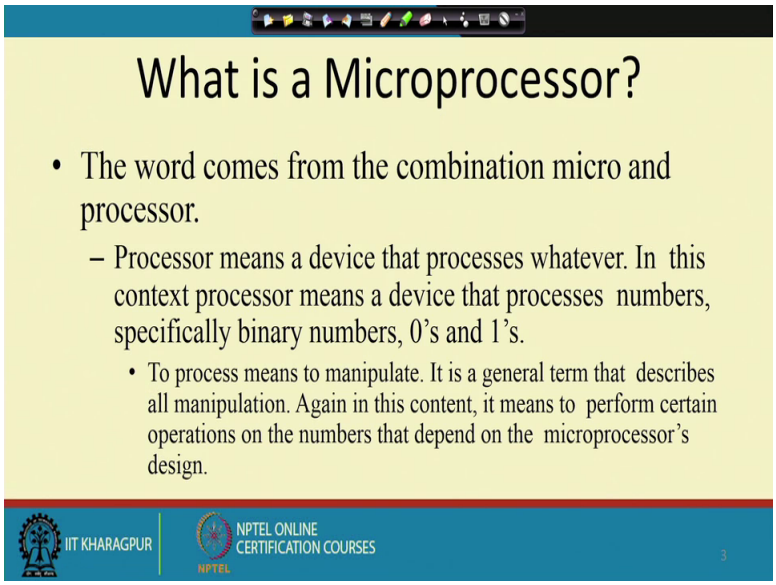

So, processor we know that it is a device that processes whatever like a, whatever data is given, it will do some processing on that. So, processor is a device that processes numbers specifically binary numbers when we are talking about electronic circuit it is a processing of binary numbers zeroes and ones. So, processing means to manipulate the

numbers, whenever a device is doing those manipulation so that is a processer. So, when we have party we have electronics engineers. So, we will be talking in terms of electronic circuitrs, we will be talking about the electronic component which does this processing. So, they will be called processor.

So, it is basically describing all type of manipulation. So, certain operations we performed on the processor and what are the operations that we can do on this numbers that is defined by the microprocessor design team. So, they actually have told like what are the operations that you can do with the data set in this microprocessor. So, accordingly that microprocessor will be able to do those operations only. Similarly if that is true for any other processer design of course, not only specific for microprocessor.

Now, processor part we understand in the term microprocessor, what about the micro term. So, micro, it is in late 1960s, processors built with discrete element. So, just sometime back I was talking about it that you take discrete elements like you take the ALU separately, you take the registers separately, so that way we combine them together into something and that into one design and that way we get the processors. So, that way these devices are perform to the perform the required operation, but where two large and two slow. So, the naturally they are footprint will be large. So, as a result the resulting circuitry or the design the device that we have so that will be larger in size, so nobody will like that and you can easily compare the electronic components that we had in 1969s and the electronic appliances that we have now. So, size there is a huge difference. And not only size the power consumption performance everywhere it is improving and one basic reason for this improvement is that we could miniaturized the whole system and we could put this the design into a single chip.

So, in 1970 the microchip was invented and all the components that made of the processor and now placed on a single piece of silicon. So, the size becomes smaller and speed become much much larger much much faster. So, that way the microprocessor was born processor was and with the invention of this microchip then this microprocessors came into existence.

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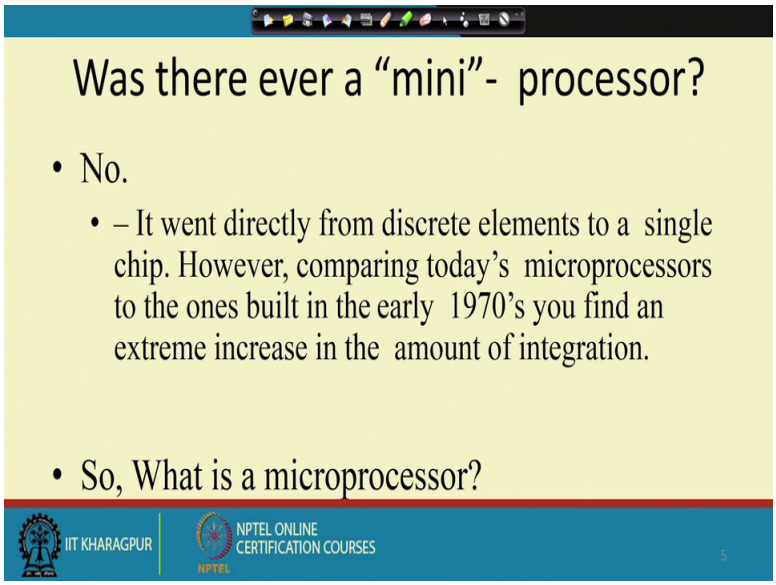

It essentially raises a question like was there any mini processor somewhere. So, processor, mini processor, microprocessor can it be like this, answer is no, it directly went from discrete elements to a single chip. So, there were no intermediary point in between. However you can say that comparing at today's microprocessors to the once built in 1970s, you can find an extreme increase in the amount of integration. So, that way you can say that something was mini processor, so if you like. But as such in the technology there is no such term called mini processor though that is that is minicomputer which was of mini which was the smaller than main frames. So, that way minicomputers are there, but mini processor there is no such no such concept.

So, what is a microprocessor? So, if we tried to answer this question.

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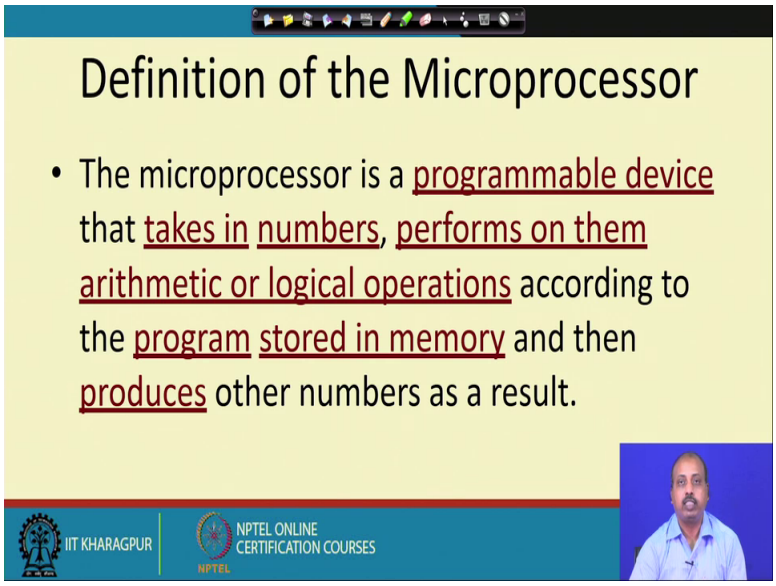

So, a microprocessor if you define to a le man, you can say that it is a programmable device that takes in numbers, perform some then arithmetic and logical operations according to the program stored in the memory and then produces other numbers as a result. So, this is the overall operation of the microprocessor without going into the design part of it. So, we will go by this individual terms like programmable device takes in the, what is the input it is taking, what sort of operations it can perform and on the what it can do the perform.

So, one is the type of operation and another thing is on which, what are the operands on which it will do the operation and finally, what is the result that it produces. So, we will try to answer all these when we go into the definition of microprocessor.

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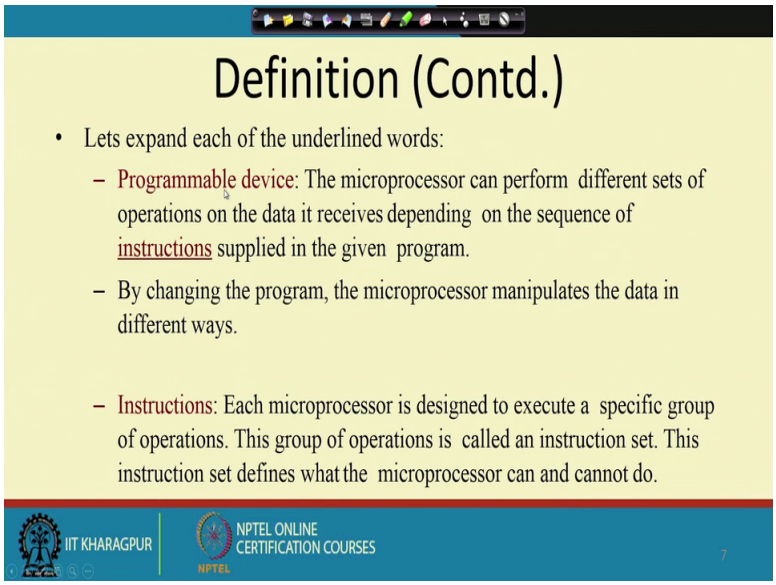

So, first term that we have is a programmable device. So, this is the best thing. Like if I am asked to design some circuits I can design the circuit which will do that operation only. For example, if I am asked to design a circuit that will that will scan one input bit stream and whenever it finds the pattern 4 ones followed by a 0. So, it will output a 1 otherwise the output bit is 0.

So, if we design the circuit by means of some, by means of some flip flops and gates and all that in from our classes in digital logic we can. So, that circuit will be able to do that operation, but it is dedicated for doing that operation only. So, programmability is not there. It is dedicated for that particular application.

So, microprocessors on the other hand, they are programmable device. So, they can perform different states of operations on the data it receives depending on the sequence of instructions supplied in the given program. So, microprocessors they are guided by the instructions. So, almost, all the microprocessors they will have a reset pin and if you reset that microprocessor. So, it will start looking into the memory from a fixed address and from that address that it will expect that there will be an instruction in that address. So, it will take that instruction execute it then it will upgrade its program counter type of registers so that it points to the next instruction and that way it will go on.

Now, if there is no valid instruction at a certain memory location then what the microprocessor will do. So, that is not defined. In fact, that depends on the way the

microprocessor has been designed. So, whatever, so at the beginning of a every such cycle what the processor will do it will try to get the next instruction from the memory and if that instruction is not meaningful to the processor then some exception situation will occur and how that exception will be handled, that is defined by the designers of the microprocessors. But anyway assuming that there is there is no such erroneous cases. So, we have got microprocessor getting correct instructions and execute engine.

So, today maybe I have a microprocessor that scans the say the temperature of a room and accordingly monitors the temperature of a room and that way it first reads the values from the sensors, temperature sensors then it turns on say ACs or heaters depending upon the safe temperature value and the deviation from that.

So, if tomorrow you want that same microprocessors to do something else not the temperature monitoring, but maybe say your conveyor belt monitoring the conveyor belt control operates the application. So, in that case the microprocessors, the program part needs to be changed and they same the microprocessor will remain same only the program that it was executing will change. So, in the memory now you have a different program so that the microprocessor will do something else. So, that is what a programmable part. So, you can change the program part to get some other job done by the microprocessor which is not possible by any arbitrary digital circuit.

Then the instructions second part is the instructions. So, each microprocessor is designed to execute, a specific group of instruction a specific group of operation. So, this is called an instruction set. So, if you look into any microprocessor the first thing that you should do is to look into the user manual and the user manual, it will be detailed like what are the instructions that this processor will support. And while writing programs, we should write following those instructions only. And many time, we do not know all these things because we write our programs in some high level language and then like say C or Java or C++ something like that and after that there will be a compiler with the compiler will compile the program and it will translate it into the language that is known by the underline processor.

So, if today you are running your c program on a on a computer system that has got 8085 as the basic processor. So, this compiler will should generate the code which is understandable by the 8085 processors, so the instructions that is understood by 8085.

Tomorrow if it is some other system on which we have got the same program to be executed, but say the underline processor is different, so it is a arm processor in that case the compiler that you should have there. So, the compiler should be translating the program into the language which is understandable or the instructions that are there understandable by the arm processor.

So, that way microprocessor will finally, understand the set of machine instructions, then that is told that is fixed by the designer of the microprocessor. So, that is not in the hand of the user. So, user has to write the program using those instruction that are available.

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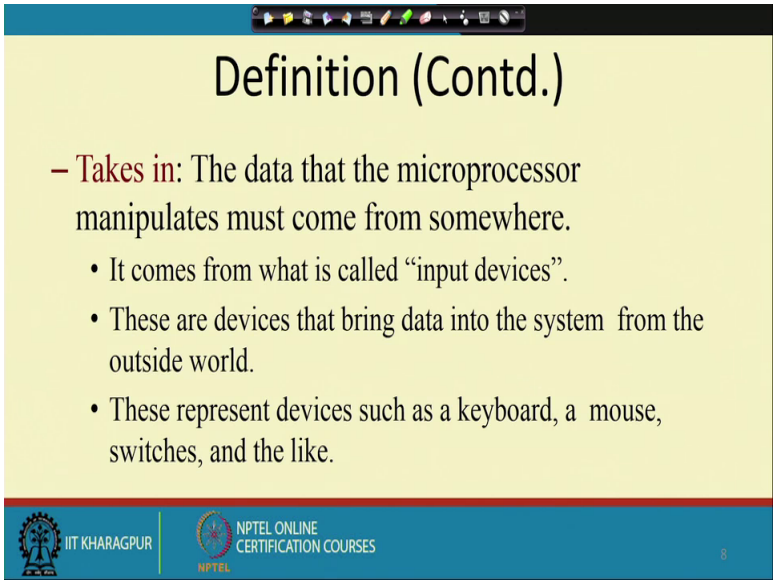

So, next part is that takes in. So, what is the value that it takes in? So, I said that it does some manipulation on the data that it takes. So, it can come from the input devices. Like I can have a number of peripheral devices connected to the microprocessor. So, we have seen that any processor can be connected to the memory as well as it can be connected to the IO devices.

So, memory can also be treated as an input device if you note down the input values for a program in the memory itself. For example, if the job is to sorts say 100 numbers and in the memory itself I store the 100 numbers. So, what the processor will do? It will do it will operate on those 100 numbers stored in the memory. On the other hand if it is like this that I have got a temperature sensor installed and a while operating. So, the system we should take temperature from that temperature sensor. So, in that case it is the coming

from the input device which is the temperature sensors. So, this way it will go on. So, that way, input devices it may vary and the input come from the input devices.

So, these are the devices that bring data into the system from the outside world. So, this is the interface to the outside world and the problem is that in outside world is in general analogue in nature. So, though we are designing digital circuit of the microprocessors they are operating with digital data, the outside world is analogue in nature. So, accepting some very simplistic type of inputs like say is a particular switch whether it is on or off a particular light whether it is on or off accepting this type of input so what you have is a continuous data. So, for example, if I say this temperature sensing, so temperature sensor, it will generate a range of voltages depending on the temperature that it is getting. So, it is not a digital one.

So, many times what happens is that from the input device to the processor, in between we have some sort of data converters and some of the processors are equipped with those data converters like analogue to digital conversion for the input part and digital to analogue conversion for the output part. So, that the processor handles digital data only, but it can talk to the outside analog world through these two ADC and DAC converters. So, what is happening is that this devices they bring data into the system from the outside world and there can be devices like keyboard, mouse, switch, all these they can be treated as input device.

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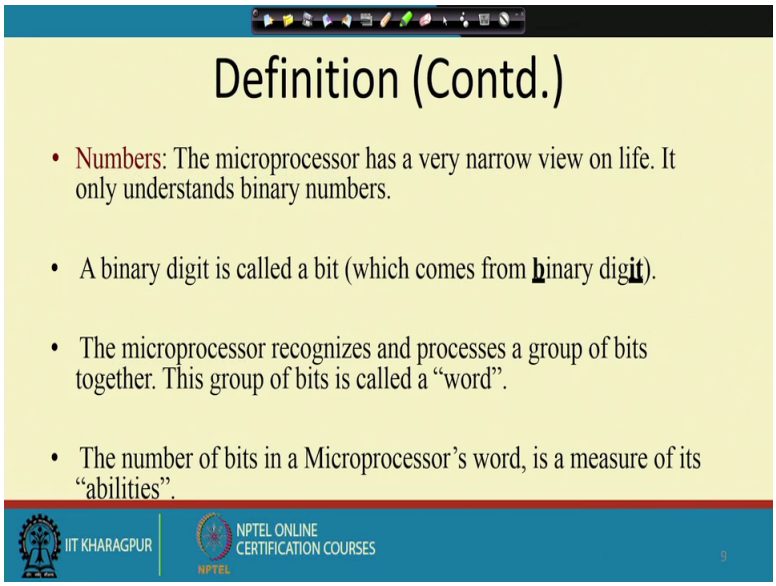

Next part is the numbers like how are the numbers manipulated. What are so, so what are the values that it can have. So, while we are talking to our, this universe, this numbers are can be very large. So, this, for example, if I talk about integer numbers say. So, integer number it can have values up to infinity it can be arbitrarily large, but what happens is that when you are putting it inside a computer a number. So, this you cannot give infinite storage to store the number. So, you have there will be a finite size. So, that way you can some sense I can say that the microprocessor has a very narrow view of life. So, integer if you are dedicating say 16 bit to it, if you are considering both signed and unsigned integers then it can go from minus 3 2 7 6 8 to plus 3 2 7 6 7. So, that way there is a range.

So, that way the microprocessor it has got a very narrow view of life we can say and it only understands binary numbers, so only zeros and ones not the octal hexadecimal integers like that. Though for our own understanding many a times we even represent binary numbers using this octal and hexadecimal notations, but inside the processor it is always the binary number system that works. And a binary digit which is also called bit so that is how the numbers are stored because this the bit 1 is stored as a high voltage value or the somehow it is been taken as logic level high and 0 represent the logic level low.

Now, a microprocessor recognizes an process is a group of bits together which is and a group of bits is called a word. So, like if I am working with some two, in a two integers, this integer what is the size of the integer or when I am getting an instruction this instruction for that the processor can handle, it should have a finite size. So, what happens is that this processor it always talks in terms of words is a collection of bits. So, a word maybe consisting of say 16 bit, a word may consist of 32 bits, that way it can consist of number of bits that is fixed by the designers. But when it is doing the basic operations like addition, subtraction, multiplication, division, comparison, all this operations then they are operating at the word level. So, this is fixed by the processor designer what is the word size for the processor. So, for the microprocessor also that is same.

The number of bits in a microprocessor word is a measure of its abilities. So, why do we say this? So, when I say a microprocessor is an 8 bit microprocessor. So, it means that it can operate on 8 bit values. So, when I am doing addition. So, I have to keep in the

integer addition, it will be only 8 bit numbers and the result can be 8 bit plus 1 bit carry total 9 bit. Or if so, if I am talking about powerful processor; that means, it will be able to handle larger values the difficulties that if you are having smaller sized numbers then in a basic step the processor will be able to do operation on those smaller size data.

So, if you are if the basic processor is supporting say 8 bit addition and now I am interested to do a 16 bit addition I have to implement in software this 16 bit addition in terms of 8 bit additions. So, I am not saying that this is not possible, but this will take more time compared to the case in which a processer handle 16 bit word and a 16 bit addition is done in a single shot. So, that way we can have the difference between these microprocessor capabilities.

So, today the microprocessors that we have, 8085 is 8 bit word, but if we look into today's microprocessors. So, they are having 32 bit 64 bit word size. So, that way it can handle much larger data.

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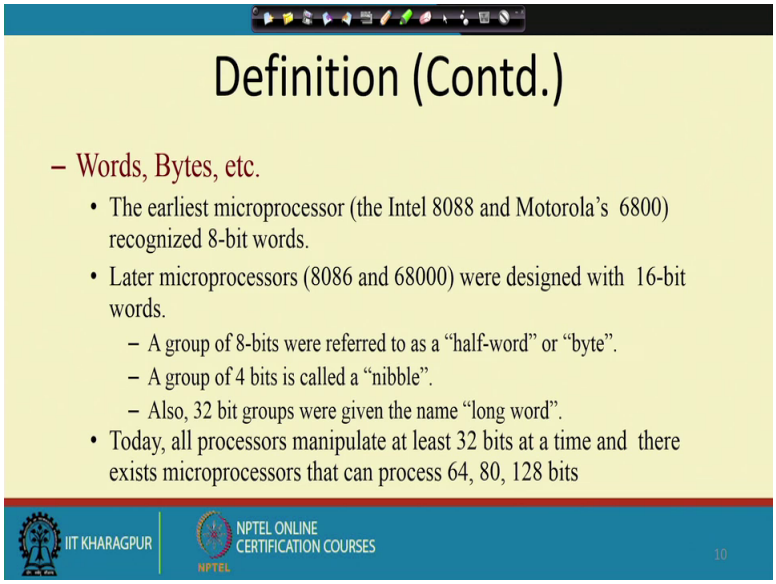

So, words bytes etcetera. So, that the earliest microprocessors they recognized 8 bit words, so 8085, 8088 and this Motorola 6800, 6800, they are all they handle 8 bit words. So, processors like 8086 and 68000 they were designed as 16 bit word.

Now, there is a small thing to notice here that Intel 8086 and this number is 8088. So, why this 8088 been coming later as the name suggests. So, this processor came later than

this 8086, but why this is 8 bit and 8086 is 16 bit. The reason is like this that 8085 came before all these 8086 and 8088 and it was very popular, it was a very popular processor and then many systems are developed using 8085 and 8085 it has got 8 bit word, so this the number of pins the data lines that comes out of the processor. So, that was 8 bit.

Now, tomorrow when this 8086 was introduced into the market. So, you cannot just take out this 8085 chip and put the 8086 chip there because of the simple reason that the database size itself got changed, from 8 bit it has become 16 bit. So, it becomes the hardware becomes incompatible.

So, after I understanding this thing for Intel did is that they just went to one step back and make 8088, one 8 bit processor though its internal operation is exactly similar as 8086. But from the outside world, it is an 8 bit word interface, all the systems in which 8085 was being used, they can be replaced by this 8088 processor and the hardware remains unchanged. So, of course, the software has to be changed because that will be now for 8088, but the hardware part do not need to changed.

So, this microprocessors we had 16 bit word. A group of 8 bits we call it a half word or a byte. So, word is if we call a word to be 16 bit of course, there is no standardization, standard thing like this 16 bit word. So, we can have some processor with 32 bit word 64 bit word or as byte is a very standard term. So, 8 bits constitute a byte, but this word size is dependent on the processor.

So, if we say that a word size is 16 bit then the group of 8 bits they are refer to half word or byte group of 4 bits is called a nibble. So, if you divide the byte into two 4 bit parts, each of them will be called a nibble. So, 32 bit groups, they are often named as long word of course, again the same thing.

So, this is a bit non standard because it depends on the word size of the processor. And all processors today they manipulate at least 32 bits at a time and there exist microprocessors that can process 64, 80 or 128 bits also. That way we can have much larger capability, capability wise much better processors in which we can manipulate larger data bit in a single instruction.