Digital Circuits
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Lecture – 48
8085 Microprocessor

We will start with the 8085 Microprocessor. So, this is one of the examples of digital circuits the, that realizes a complete processor. So, it is a complete central processing unit or CPU, we can say that does many operations and it can be so this is one of the basic unit that is there, when you are looking into any computer system. And this does all the computation as well as the control of the other chips, and circuitry that we have in the in the in the processor board or in the basic circuit board that you have.

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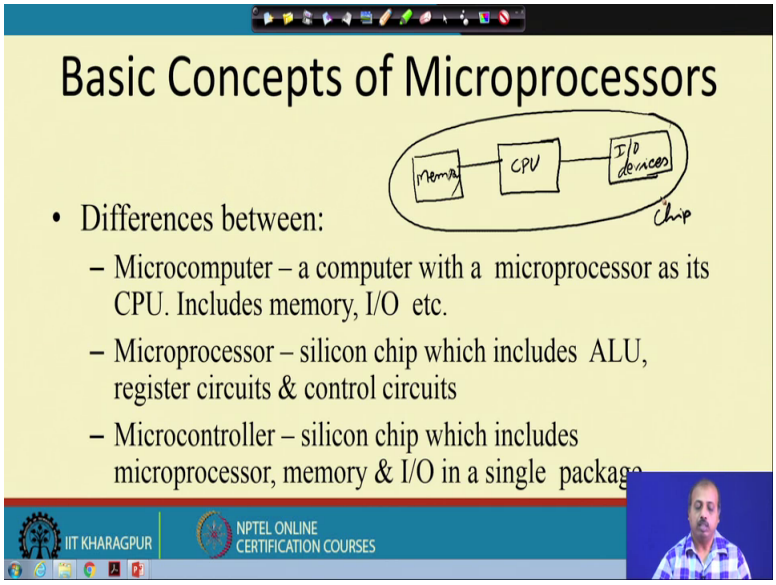

Now, so if you look into these microprocessors, so they are some microcomputer is a computer with a microprocessor as its CPU. So, to start with you can say that a from a computer system, so it is consisting of the components like the central processing unit or CPU that does all the computations. And then there is a memory unit from where so which actually holds the program to be executed by the CPU. And then it has got the CPU is also connected to some input output devices or I O devices.

So, of the way any computer system works is like this that the CPU it opts the memory for the next instruction to be executed. So, it has every CPU has got a certain fixed set of

instructions that it can understand and it can execute; so, this after getting the next instructions, so it will execute the instruction. And in the process, it may need some input from some I O device, or it may need to output some value to some output to some output device. So, this is the basic operation, though so CPU it accepts the instructions from memory. And produces output may be (Refer Time: 02:15) to some part of memory or to the input output devices.

Now, when we are talking about a microcomputer, so a computer that has got a microprocessor as its CPU. So, this so apart from the micro apart from the microprocessor, so it will also have memory, input-output modules etcetera. So, what is a microprocessor then, so microprocessor is a silicon chip that includes one unit known as arithmetic logic unit, it has got some registers, and it has got some control circuitry to control the operation of this registers. Then this ALU, and the instruction fetching and decoding instruction fetching decoding from memory understanding their types etcetera.

So, microprocessor is a basically a single chip, you can say it is a single chip CPU ok. So, there can be this discrete component the CPUs, which was there in earlier systems; But, now almost all the computers that you see, so they host a microprocessor which actually takes care of the operations. And then we have got microcontrollers also, where this entire CPU memory and I O device, so they are put into a single chip. So, this whole thing if you put into a single chip ok, so then what you will get is a microcontroller ok.

So, it has got advantage, because this in that case this memory to CPU communication or say I O device to CPU communication, so it is not off chip. So, it is within the chip as a result, it is quite fast. On the other hand, so in normal system or normal computer system was a CPU to memory communication is a bit slow, because that is off chip communication. So, via some other signal lines particularly the metal lines, which is not on the silicon floor itself, so that makes this off chip communication slow; So, the microprocessor, it will be bit slow; some of in many cases as far as this communication is concerned compared to microcontroller.

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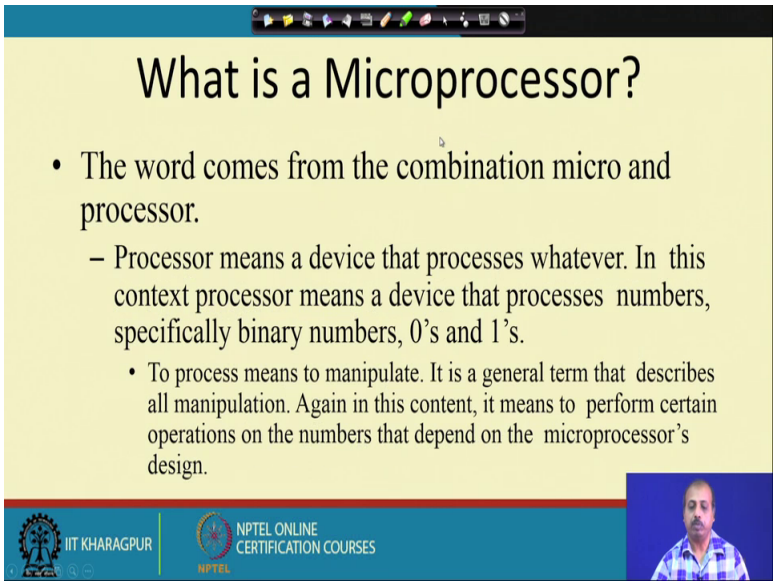

So, so in this course, we will be looking into these microprocessors in more detail. So, what is a microprocessor? So, if we look into the term and the word comes from the combination micro and processor. So, what is a processor, so processor is a device that processes whatever. So, whatever is coming as input, it will process it.

Now, if whatever it comes so it may be meaningful to the processor, it may not be meaningful to the processor. If it is not meaningful to the processor, it will simply ignore it; or it will give some error output. And if it is meaningful, then it will execute it. So, processor is a device that processes numbers, specifically binary numbers, 0's and 1's. What do you mean by process, so processing means to manipulate. It is a general term that describes all manipulation. And again in this context, you can say that it means perform certain operations on the numbers that depend on the microprocessor's design.

So, microprocessor design that they have told like for a particular microprocessor, they decide like what are the operations that I will support in this processor. Accordingly what should be the format in which this instructions be given to me and all; And then this processor once it gets instructions in that format, it can execute it using its internal resources like this ALU the arithmetic logic unit, and the registers and all.

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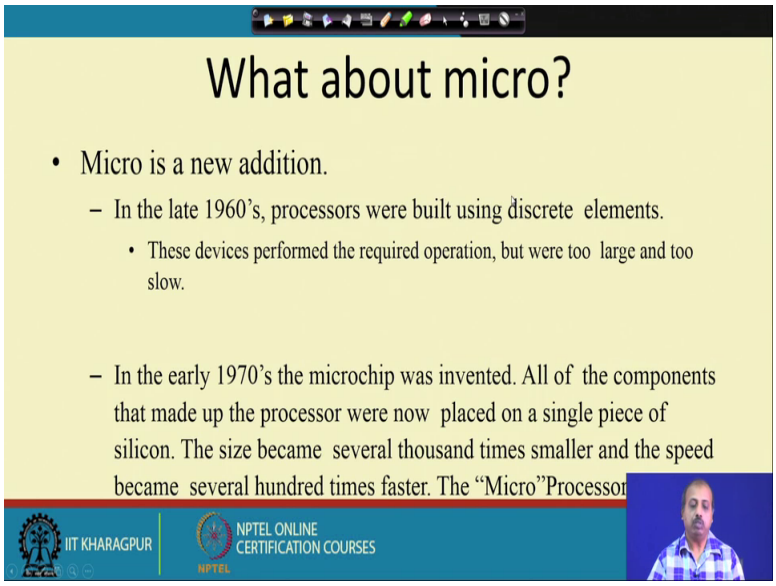

What about micro? So, micro it is a it is an addition. In fact, you can say the late 1960's, so processors were built using discrete elements. As I was telling I can have this separate registers clubbed together into one block, and then you can have this controller design separately. I can have this instruction fetch unit, which fetches instructions from memory separately that way I can have different different processors; I can have ALU separate. So, this type of designs, so they were known as bit sliced design. But, the problem with their that type of design is that since they are all the components are discrete components, they are discrete chips, or then the communication between them takes lot of time.

So, from this microprocessor actually trying to reduce that time so, this is in 1970's thus the microchip was invented. And all, the component that that made of processor when now placed into a single piece of silicon. And the size became several thousand times smaller, and the speed became several hundred times faster ok, so that is how the microprocessor was born. So, if we can take this off chip things into on chip as I already said, the speed will increase. And naturally the space requirement will also go down, because there is no off chip connection.

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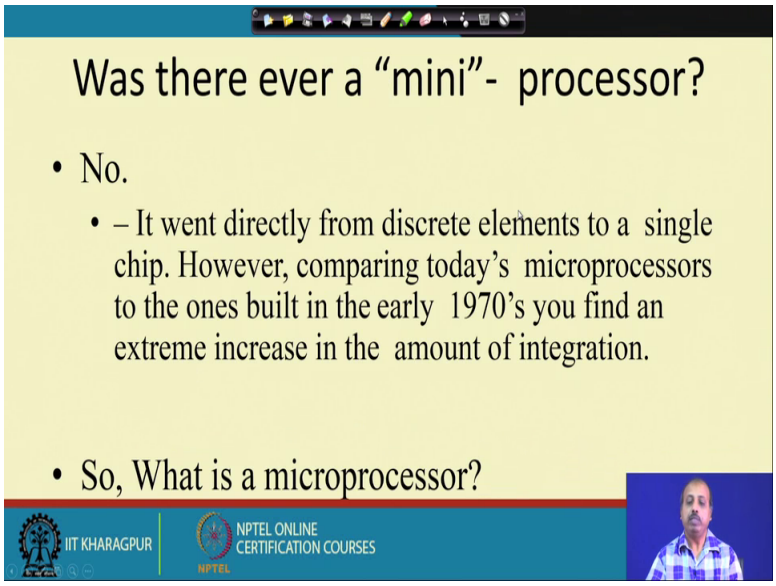

Was there any mini processor that way? So, we are talking about general processor, we are talking about microprocessor. Was there any mini processor? The answer is no. It went directly from discrete elements to a single chip. However, comparing today's microprocessors to the ones built in early 1970's you can find an extreme increase in the amount of integration. So, this 8085 it is one of the very simple processors that we will look into.

But, if you look into today's processor that, are used in the computer systems today, so they are so complex that it is very difficult to cover in a single course. So, the it several components are designed with high level of optimization. And with integration between the this processor designer, operating system designer, programming language compiler designers and all, so that way it makes it very complex. So, what is a microprocessor?

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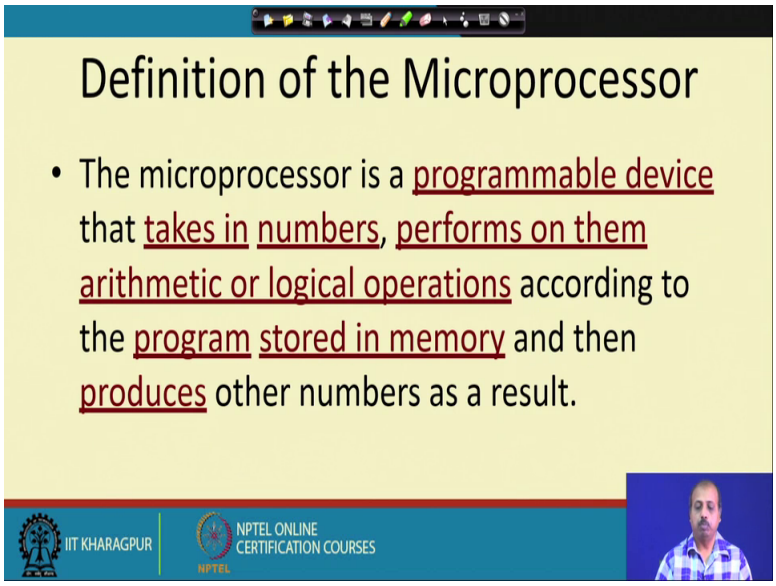

So, microprocessor is a programmable device that takes in numbers, performs on them arithmetic or logic logical operations according to the programs stored in memory, and then produces other numbers as a result. So, this is the very general definition of a microprocessor.

So, if you look into these terms one by one, so it is a programmable device. So, you can tell the microprocessor what to do ok. And that program is has to be stored in some memory, so as it is said here. So, the program should be stored in some memory. And from there, it will be doing the operation; it will take the instructions from there.

Now, it will so if any particular instruction, so this talks about manipulating some numbers ok. And this numbers may be coming from the memory itself; or it may be coming from the input output devices the input devices. And then on those numbers that the processor has got, so it will do some operation. And those operations may be some arithmetic or logical operations.

So, those arithmetic logical operations are basically done by the ALU; or the arithmetic logic unit. And then some output is produced. And this output that is produced, so it may be stored in the memory or it may be stored in some it may be flashed onto some output device, it may be sent to some output device for some further understanding or processing.

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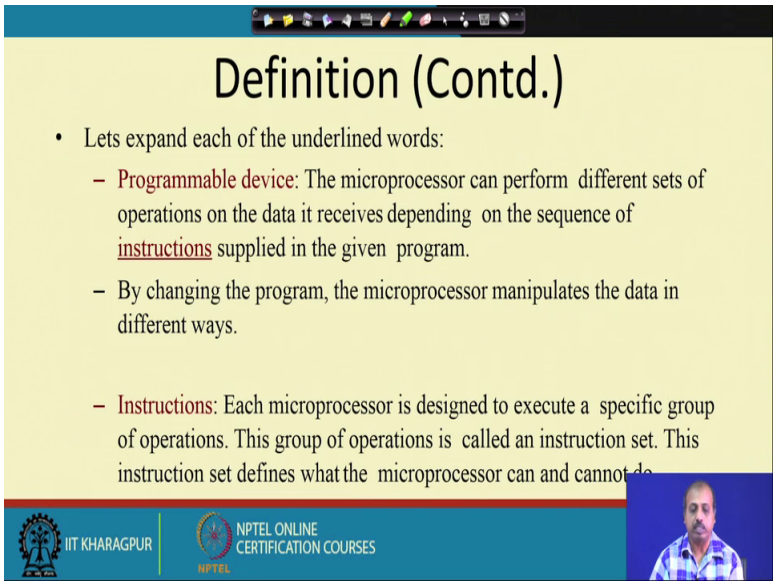

So, this is the definition of basic microprocessor. So, if we expand these terms one by one, so what a programmable device, a microprocessor can perform sets of operations on the data it receives depending on the sequence of instructions supplied in the given program. So, if the microprocessor works with a program and the program is stored in the memory. And this program will tell the instructions that the microprocessor should execute. By changing the program, the microprocessor manipulates the data in different ways definitely, so that is why the term programmable ok. So, this is a programmable device, so that is you can program it, but it is very complex device.

Then the instructions that a microprocessor can execute: So, each microprocessor is designed to execute a specific group of operations. And this group of operation is called the instruction set. So, today if you are designing a new microprocessor, then the first thing that we have to answer is: what is the instruction set that we are planning about. So, what is the instruction set of the microprocessor; or if you come cross a new microprocessor and try to use it, then the very first thing that we will get stuck with is: what is the instruction set for the microprocessor. So, what are the instructions that are supported by the microprocessor.

So, any processors study or processor design, it will start with the instruction set. So, this instruction set will define what the microprocessor can do, and what it cannot do. So, anything which is not documented in the instruction set, so that cannot be done by the

microprocessor. So, sometimes this appears to be a bit whimsical, because you may find that some operations are done, whereas some other operations are restricted. So, apparently it seems that why restriction, but that comes from the design side, may be the designers for their ease of design or some constraint in the design modified the operations like that.

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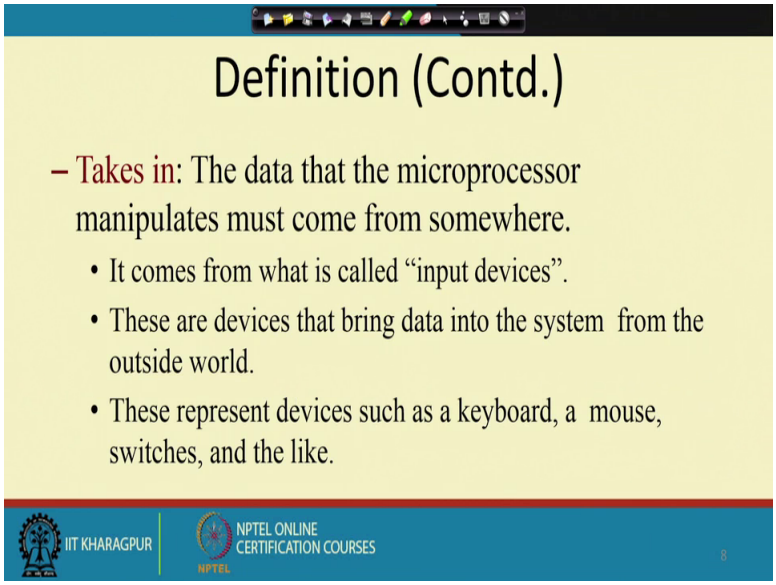

What does it take in, so it takes in the data from the that from somewhere ok. So, where from, so it can come from input devices like in a computer system I can have a keyboard, a mouse, or even may be some I can have a signal line, which may be made high or low. So, these are called the these are the inputs for the microprocessor.

So, this input devices, they can give that data the data for the microprocessor to work on. So, these devices these are the this input devices are the devices that bring data into the system from the output world. And these represent devices such as keyboard, mouse, which is like that, so that is the takes in.

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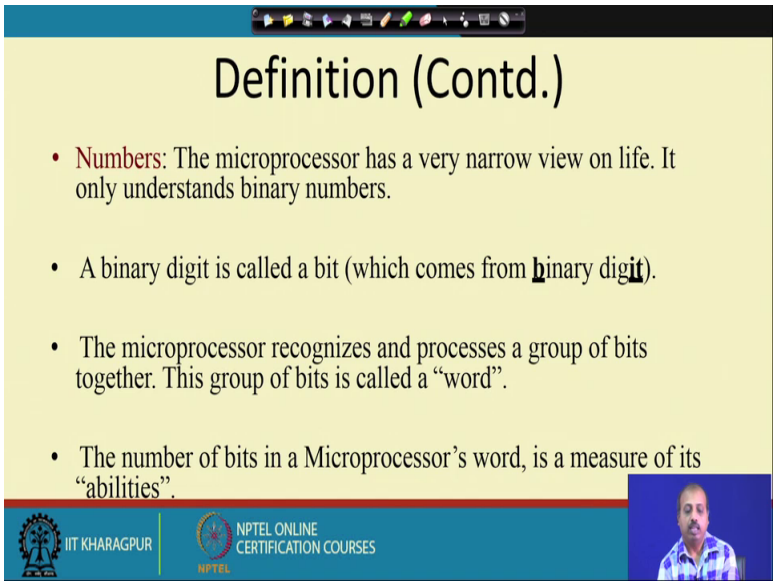

And what do you mean by numbers, so numbers a microprocessor has a very narrow view of on life, you can say it only understands binary numbers. So, it is this statement is slightly you should say this is tricky, because as we know that any digital system it works with 1's and 0's only, so that is true for microprocessors also.

Though while understanding the operation of a microprocessor, we will see the, we will write in terms of some text some asci characters and all ok, with some mnemonics, and variable, register name and all. But, internally everything is nothing but some binary numbers. A binary digit is called a bit, it is binary digit. a microprocessor recognizes and processes a group of bits together. And this is called a word.

So, in our digital logic classes, so we know that we have got this bit representation binary representation or individual bits are there. Now, the when this microprocessor is can they considered, so it may not work with individual bits that way. So, it may work with a group of bits together, which is called a word.

For example, when it is getting instructions from memory, so it may be each instruction is say 8-bit or 16-bit wide. So, as a result when it is getting the instruction, so it is getting a (Refer Time: 14:07) fetching 8-bit from the memory; or if it is the doing some addition operation, so it is not bit by it is not bit by bit addition, but addition of two words, where each word is 8-bit ok. So, we have talked about full header, half header etcetera, while it was operating at beat level. But, here this is we will be talking at the word level, where

the word size is the size is the number of bits with which the processor works or the microprocessor works.

So, the number of bits in a microprocessor's word, is a measure of its ability. So, if a microprocessor is powerful microprocessor, then it will be able to work with larger size (Refer Time: 14:47) word like. If we are if we say that a microprocessor is 8-bit microprocessor, so what we essentially mean, is that all the operations that it is doing is on 8-bit data. So, doing operating on 8-bit data is problematic, because then you can have positive numbers. If you are thinking about positive numbers, so you can go from 0 to 255 and both positive and numbers, so minus 128 to plus 125, so that is the sever restriction.

On the other hand, consider the situation where the microprocessor is a 16-bit microprocessor, it can do 16-bit operation. So, internal circuit till that it has can handle 16-bit of data at a time so, in that case, the number that we have. So, now the range of their ranges and all, so they are much larger, so that way it may be useful for us. Like if a microprocessor supports only 8-bit say addition, then definitely you can use that 8-bit addition to get 16-bit addition. But, that will be in terms of a number of instructions for the microprocessor, so that is basically a software solution I can say.

So, if I have got 216 bit numbers to be added, so we can first add the least significant 8 bits. And if there is a carry, then that carry is transferred. And then in another instruction, we add the most significant 8 bits. And then another instruction, we may add the carry coming from the first stage to the second stage. This way the single 16-bit addition can be realized by say 3 8 8-bit addition. But, the time taken is more compared to the situation that if the microprocessor directly support supported 16-bit addition by a single instruction I could have done that 16-bit addition.

So, this way whatever is limited by the hardware in the microprocessor. It can be done by means of software, by means of program statements, but that will make the system slow. So, output will be the it will take quite some time to get the output.

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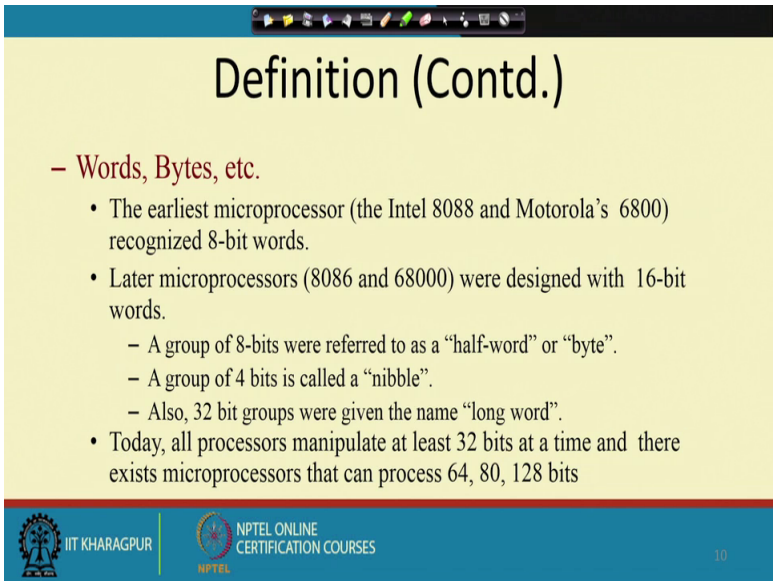

So, the earliest microprocessors like say Intel 80 8008 and this 8088 and Motorola's 6800, so they recognized 8-bit words. In fact, 8085 also recognizes the 8-bit word. Later microprocessor like 8086 and 68000, so they are 16-bit words and then the group of 8-bits are referred to as half-word or byte. And a group of 4 bits is called a nibble. So, word size with a word size is 16-bit, then half of it is half-word or byte. So, word size can be say 32, 64 even 256 bit word size is also common ok, so that is there. So, it may be divided into smaller parts. So, a group of 8-bit will be called a byte, group of 4 bits will be called a nibble.

Similarly, if you take 32 bit group, so they are often called long word. So, all processors manipulate at least 32 bits, most of the processors that we have in today's time, so they manipulate at least 32 bits at a time and there exist a microprocessors that can handle 64, 80 or 128 bits at a time, so that way it is much larger. So, it can handle more number of bits together the word size is higher.

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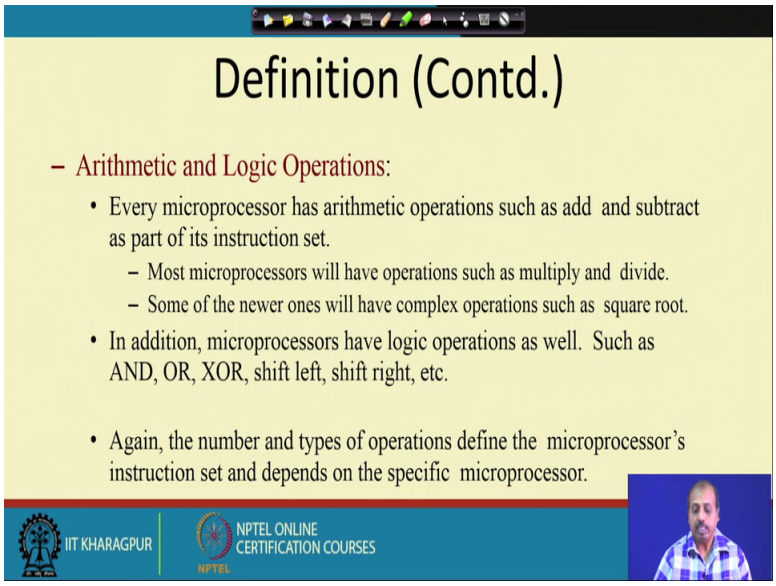

Then looking into the arithmetic and logic operations so, every microprocessor has arithmetic operation such as add and subtract as part of its instructions set, because these are the basic operation. So, if addition and subtraction are not supported, then you cannot do any of this meaningful any meaningful computation using that module, so that is why all microprocessors they have got this add and subtract as their in their instruction sets. And most microprocessors will have operations like multiply and divide. Of course, 8085 does not have multiply divide instructions, but there are processors, where you have got this multiplication and division type of operation.

Some of the newer one will have complex operation like square root. So, if you look into these digital signal processors, they are also microprocessors, but they can handle they can do even the effective operation ok. So, they can do multiply accumulate type of operation in one shot, so that way though these instructions are complex instructions. So, (Refer Time: 19:06) it may do some complex operation as well.

Apart from this arithmetic operation, microprocessors also do some logical operation such as AND, OR, XOR, shift left, shift right, etcetera. So, these are some logical operations, so that is why I say that the arithmetic and logic operations are done by the microprocessor. The numbers and types of operations define the microprocessor's instruction set and depends on the specific microprocessor.

So, what are the operations that you can do that will be determining the instruction set that the microprocessor should have. And it will have the, it is specific for the microprocessor, so it is not common, if you have the same set of instructions across all the microprocessors. But, more or less the basic operations will remain same like this addition, subtraction, then AND, OR, XOR, shifting, so this operations they remain same. Of course, the format may vary slightly from one processor to another processor.

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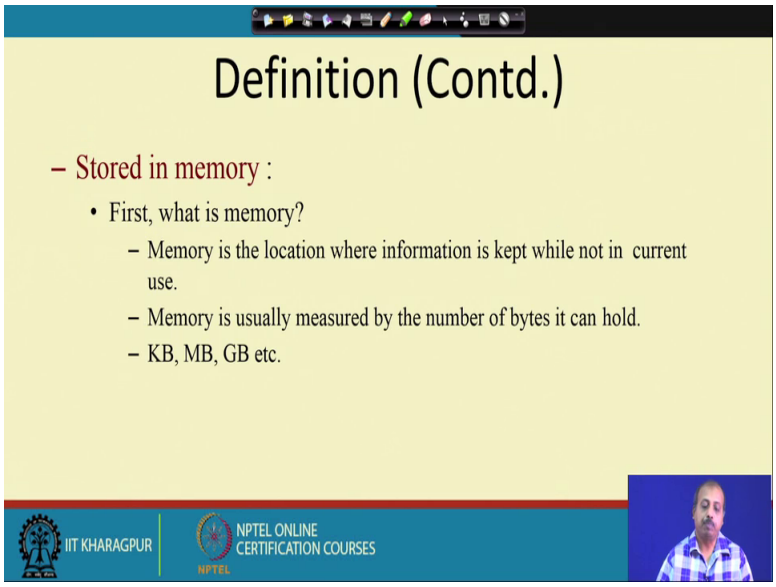

This microprocessor, so the they work with program and these programs are stored in memory that we have said. So, what is memory? So, memory is the location where information is kept while not in current use. So, here all the information are kept. And then, so memory is usually measured in terms of bytes it can hold; kilobyte, megabyte, gigabyte like that. And then that is connected to the processor. So, the processor will be getting those instructions and data from memory and operate from them, so that is the term stored in memory.

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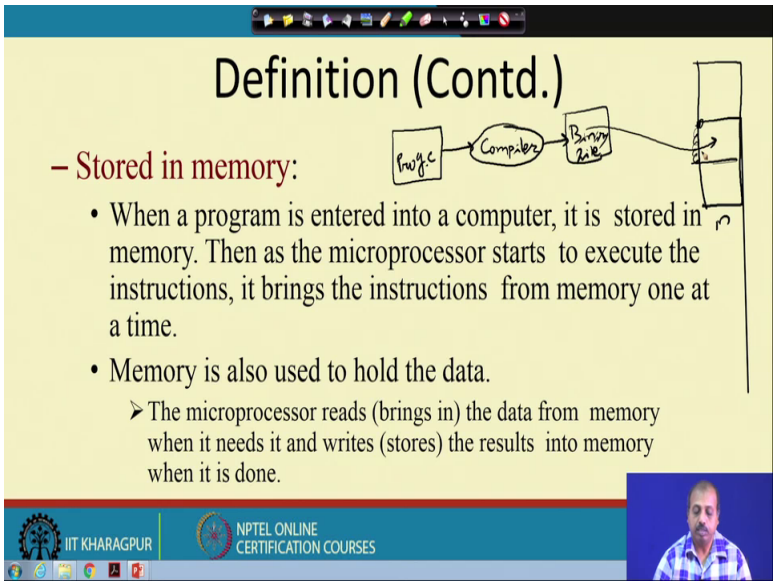

So, when a program is entered into a computer, it is stored in a memory. And then the microprocessor starts to execute the instructions, it brings the instructions from memory one at a time ok. So, what we mean is that first time we write a program first time we write a program may be we write in some language say I have I am writing in say c language, say I am writing a program which is program dot c, now this program it goes through a compilation phase. We have got a compiler, which generates the executable version or the binary file. This is the binary file executable file.

Now, this if this is the memory that I have in my system in this memory, so this binary file is loaded at some part ok. So, there may be this binary file is loaded here, and then the microprocessor when it is executing. So, it will start from the first instruction that we have, and proceed one after the other till it reaches the end of the program.

So, this program is stored in the when a program is stored in computer, it is stored in memory. And the processor starts to execute the instruction, it will bring one instruction at a time from a memory, and it will execute it. Memory is also used for holding the data like sometimes we need to hold some more data, some temporary data or some say data which is specific to some operation.

For example, if you are doing a filtering operation, then the filter coefficients they add to be stored ok. Filter signal value, so they come from the outside, but this coefficients they need to be stored. So, coefficients are stored in memory that way we can have some data

stored in the memory that is (Refer Time: 22:42) microprocessor will read in those data from memory. And after doing the operations, so it will write the result onto some memory location ok, so that is also there. It will write it on some memory location as a temporary value; and then again when it is needed, so it will get it from memory and execute it.

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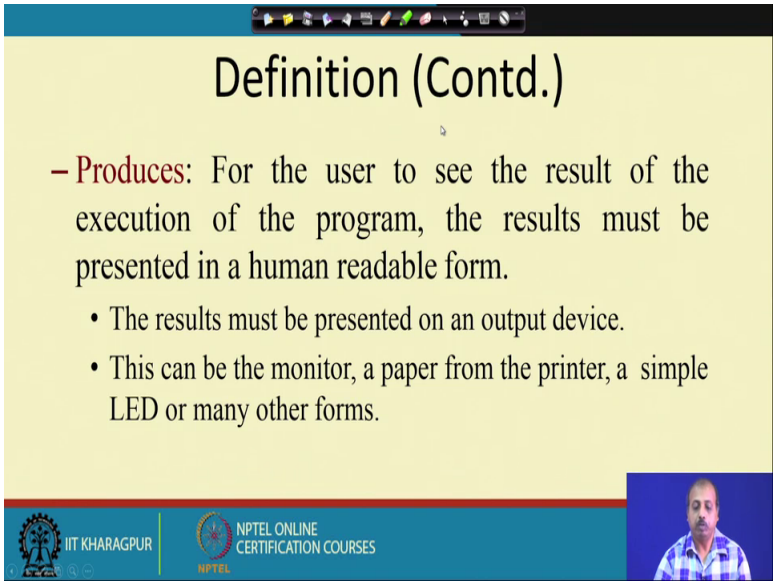

What do you mean by produces, so produces means the for the user to see the result of the execution of the program, the result must be presented in a human readable form. So, what happens is that you see you have written a program that program is a binary file, so nothing much is understandable from there. Now, the program is executing, so output is again some binary data, so again nothing is understandable nothing much is understandable from there. So, this way it is progressing.

Now, you see that if you want that to the value the whatever the value the program has computed to be interpreted or to be understood, so we need to show it in some human readable form. So, result must be presented to some output device. And this can be monitor, a paper from the printer, a simple LED or many other forms. So, in but in some output format, it should be shown ok. So, this way it can produce the data.

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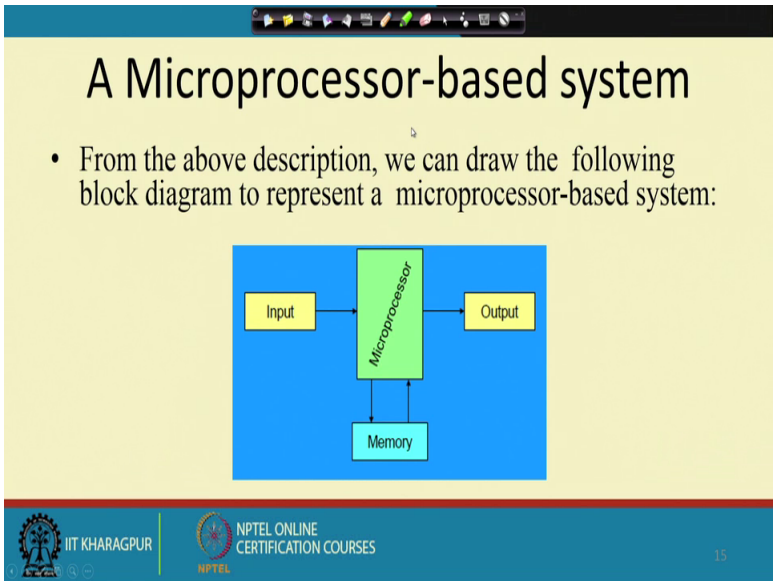

So, a microprocessor based system overall, it will look something like this. So, we have got this microprocessor and the memory. So, this microprocessor may get something from the memory or it may write something onto the memory. So, basically the microprocessor it gets the successive instructions from the memory, and it executes the instruction. The instruction execution may depict that it has to read some value from the input. So, it reads it from the input device.

And then it may say that it has to produce some output to some output device. So, it will produce it to some output device. May be as the input device we have got a simple keyboard, and at the output device we have got a set of LEDs. And the program memory that the program that is executing may be it will be reading the values from the keyboard, and then it will be producing some output pattern to the for to the LED, depending on the input value that is read, so that is actually the program. So, where it is be giving me the logic like how to produce the output from the input, so that is the program.

And it also includes the instructions to read from the keyboard, and then write onto the LED display that we have. So, ultimately when it comes to the LED display, so it is human understandable. Similarly, when we are giving the input from the keyboard, so that is also human understandable; so, this human understandability part is taken care of by the input output devices. Rest of the thing, they are taken by the microprocessor directly in term in binary form.

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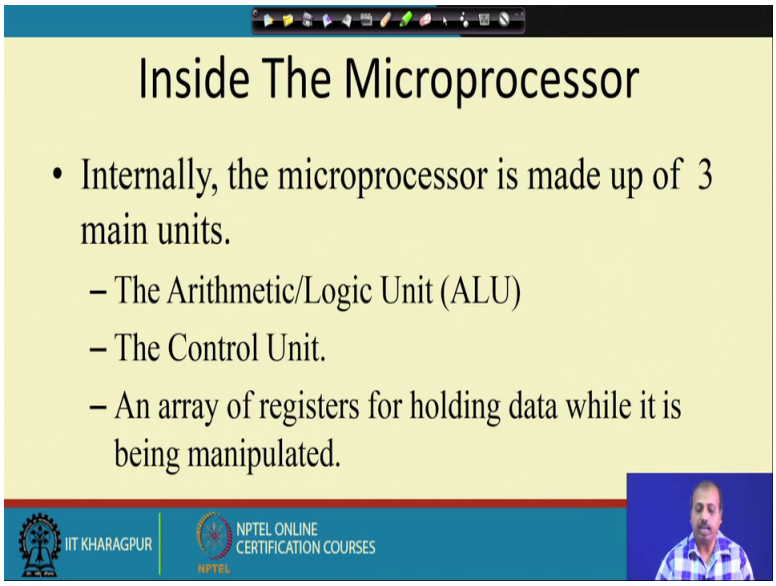

So, what do we have inside the microprocessor, so inside the microprocessor, so it has got 3 main units; one is known as the arithmetic logic unit, one is known as the control unit, and another is the array of registers for holding data while it is being manipulated; So, this basically as we have seen by this time that this we have to do some operations so some computation.

For that we need some logic circuitry and that is done by the that is the arithmetic logic unit, which will do that all the arithmetic instructions like addition, subtraction, if multiplication is supported ok, and multiplication, division, shifting ok, then this logic operations like say logic operations like the AND, OR, XOR, so all those. So, they are done by the arithmetic logic unit. So, this is one of the very important components that we have inside the microprocessor. And then we have got an array of registers that can that hold the data while it is being manipulated like if I am doing some addition operation, then the operands of the addition they are to be held at some place at some time at some register.

So, otherwise the values will change, and the addition circuitry will not behave properly. So, those additions are done, so these temporary values are stored in those registers. So, we can have a number of registers, and normally any processor has got a set of registers, where it will be doing the operation and they. So, apart from that there is a control unit,

which will be controlling the operation of all these other units in that is a registers, and ALU, then accessing memory and all, so that will be done by the control unit.