Automation in Manufacturing
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Week - 05
Signal conditioning and Microprocessor Technology
Lecture – 04
Microprocessor Technology

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In this week, we will be studying the important building block of an automated system that is Microprocessor Technology.

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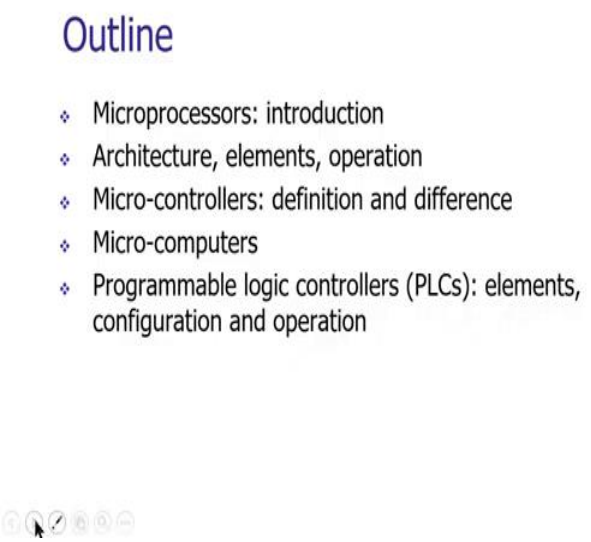

Let us look at the outline of this lecture. At start of the lecture, we will see the definition of a microprocessor; then, we will see its architecture, it has various elements, how these elements operate; then we will learn, what is the difference between a microcontroller and a microprocessor, the definition of microcontroller will be studied.

After that we will study the microcomputers, which we are using for our regular day to day activities. At the end of the lecture we will study about the PLCs the Programmable Logic Controllers which are used in the automation industry, its elements, configuration and operation will be studied in detail.

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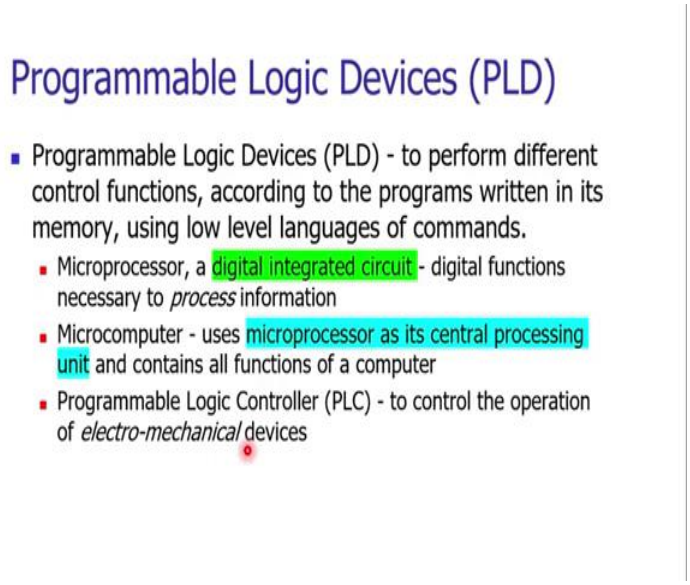

In this lecture, we will be studying various programmable logic devices. In in our previous lectures, we have seen the elements of measurement system, such as the sensors and the signal conditioning devices. After that we have also seen how we can convert the signals from one form to the another form.

Now, let us look at the fundamentals of programmable logic devices. As the name suggest the programmable logic devices has two words; these are programmable and logic. The devices which are carrying out logical operations on the data are called as the logic devices, but when the users are able to program these logic devices, then they are called as the programmable logic devices.

Programmable means we can teach, instruct and train these logic devices to carry out a certain set of instructions in the given sequence. What kind of operations these programmable logical logic devices are carrying out. They are carrying out various control functions according to the instructions written in its memory.

Whatever the commands that we are giving they are the low level language commands. The first PLD is the microprocessor. Microprocessor is a digital integrated circuit, it is an electronic circuit and carries out various digital functions, which are necessary to process the information and the data given to the microprocessor.

The microcomputer is utilizing the microprocessor as its CPU that is a Central Processing Unit and it contains all functions of a computer. Microcomputer may have memory, it can communicate with the outside world with input – output devices. We must know the difference between the processor and a computer. Processor is a simple circuit, while computer is a system; it has processor as the CPU, Central Processing Unit.

Third PLD which is very widely used i and very important as per as the automated system is concerned is PLC that is Programmable Logic Controller. Programmable logic controller also incorporates the microprocessor as the central processing unit and it controls the operations of electromechanical devices. But, PLC is working in very harsh condition. The construction of the PLC must be very rugged and robust.

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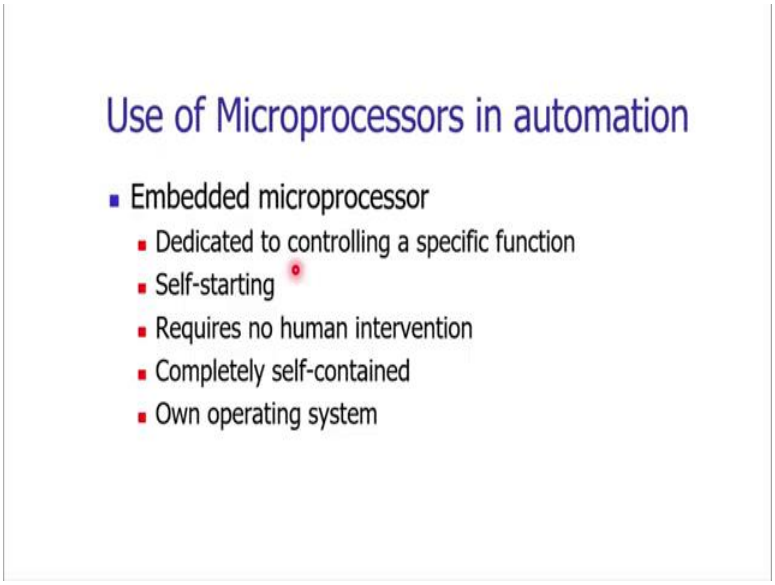

The general microprocessors which are used in automation industry are the embedded microprocessor. Some of the features of this microprocessor are: first these kind of microprocessors are dedicated to a specific function control of a specific function. For example, we want to have an automatic control system to control the temperature of an electric furnace. Here, the function is to control the temperature of the furnace.

If the inside temperature of the furnace is above the set value the microprocessor should cut off the supply of electricity to that electric furnace. A simple electronic circuitry which is embedded inside the electric furnace is nothing but, the embedded microprocessor. It is dedicated to carry out specific functions.

Second feature of the embedded microprocessor is they are self-starting. The processors are starting on their own as we switch on the system the processor will start on its own. To carry out the operations in auto mode, the electronic spec circuitry i.e. the microprocessors are used. These are completely self-contained. The embedded microprocessor has their own memory, has may have their own battery backup as well. They may have their own energy source as well. The microprocessor which are used in automation and embedded in the products or systems has their own operating system.

An embedded microprocessor will be dedicated to a specific function. It is self-starting; it does not require any human intervention. These are completely self-contained; everything is there inside the system and they do have their own operating system.

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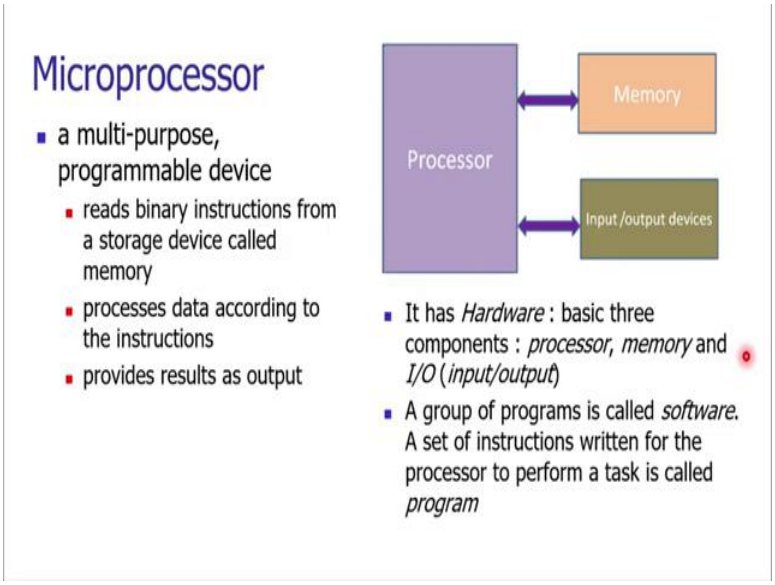

The microprocessoris a multi-purpose programmable device and basically reads the binary instructions from a storage device that is called memory. The memory may be the temporary memory or it may be the permanent memory.

Whatever the signals which are getting in, will be stored in a temporary memory. The microprocessor process this information as per the need and instructions given in the program. It processes that information according to the instructions and it provides the results as the output.

Getting the information, reading the information and processing the information based upon the instructions given are the functions of a microprocessor. To carry out these functions the microprocessor basically has three elements; the processor, memory element and input output devices. To carry out these functions, the microprocessor basically has hardware and the hardware is nothing but, the electronic parts, which are integrated together to carry out the intended operation.

The processor is an electrical circuitry, memory is an electronic part and input – output devices are the electromechanical parts. These components are integrated together, but their coordinated operation will be carried out by a set of instructions and that set of instruction is nothing but, the program and when we group together a variety of programs then it is called as a software.

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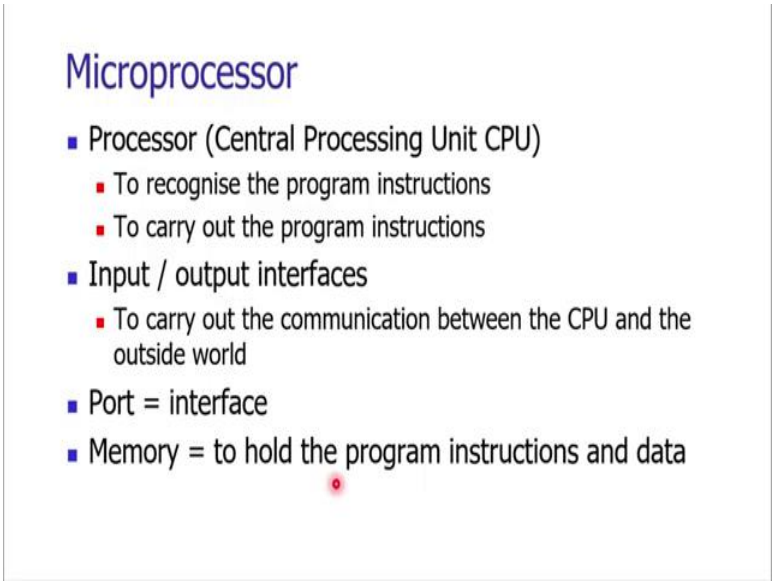

The processor recognizes the program instructions and it executes that program instructions as per the sequence given. The microprocessor has the input – output interfaces.

The microprocessor is also carrying out the communication between the CPU that is the processor and the outside world through the input – output interfaces. In general we call the interface as port in our day to day language as well we are using the word port quite often. The third element is a memory. The memory basically holds the program instructions and the data.

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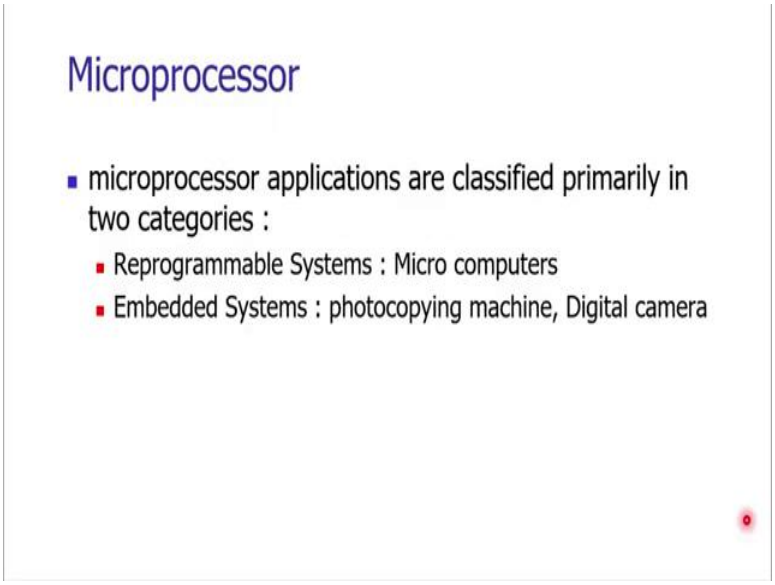

The applications of microprocessor can be classified basically in two categories. Based upon the applications of the microprocessor, the microprocessor can be utilized as a reprogrammable system device such as the microcomputer. Whatever the computing devices that we do have can reprogram these systems. We can change its operating system install some programs, modify these programs and edit the programs.

To carry out these operations in microcomputers, the microprocessor is used. When we are using the microprocessor utility for developing the reprogrammable system is called the application of microprocessor to have the microcomputers. In the second application we want to have the dedicated functions to be carried out by the microprocessor, and these are nothing but, the embedded systems.

Let us consider the typical automated system such as a conveyor belt, automated guided vehicles, automatic furnaces all the manufacturing industry equipment whether it may be processing equipment or the conveying equipment or the monitoring equipment.

Whenever we want to carry out the intended application, the desired application in automatic mode, the microprocessor is needed. The application of microprocessor to carry out specific functions in automatic mode is nothing but, the embedded system.

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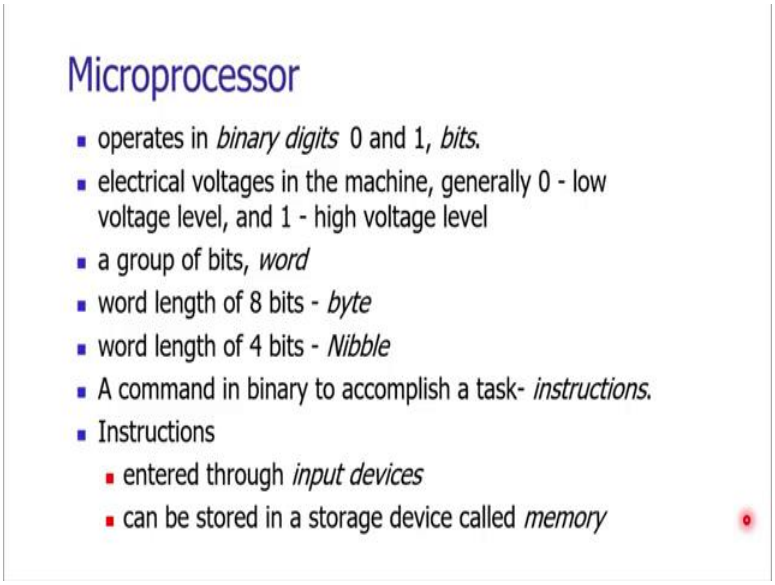

These processors do operate in binary digits that is 0 and 1. These digits are called bits. If the electrical voltage given to the machine, is of low level then the bit would be 0, and if a high voltage is applied, high electrical energy is applied then it is considered as the bit 1. When these bits are grouped together, a word is formed and if the length of the word is 8 bits, then that word is called as the byte. If the word length is 4 then it is called as nibble.

A command in binary to accomplish a task is nothing but, the instruction. Read, write, add, subtract and many operations are carried out by the microprocessors. They are carrying out the command in binary to accomplish that task is nothing but, the instructions given to the microprocessor. These instructions can be entered either through input devices or stored in the storage devices itself.

The instructions can be input by using the keyboard which is a very general input device or the pointing device and clicking device; the pointer is nothing but, the mouse; these are all input devices. But, in certain cases the instructions are embedded and stored in the memory of the computer itself.

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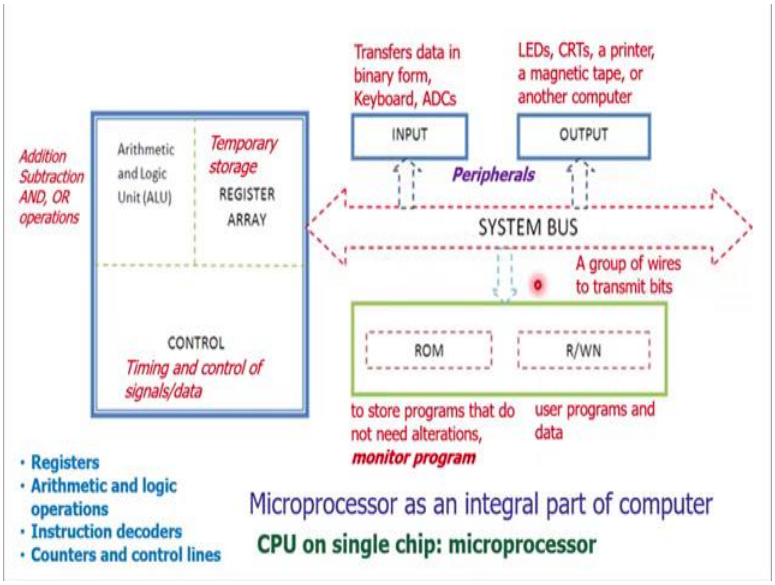

A typical architecture of the microprocessor can be seen on the screen. It has the processor which has three parts; first is arithmetic and logic unit, register arrays and the control unit.

The second set of elements is the input output devices through which the microprocessors are communicating with the outside world, and the third element is the memory. Either we can have the read only memory, permanent memory or the random memory where we can read or write and the erasing operations are possible.

To communicate with these input – output devices and the memory, we require a mechanism. Mechanism is the communication which is through the wires. Through wires the electrical signals are passed and a set of wires is nothing but, the bus through which various elements of the microprocessor are being communicated.

The register array has many registers which are utilized as temporary memory locations through which the microprocessor is carrying out a variety of operations. It is carrying out the algebraic operations as well as the logic operations. Algebraic operations are the addition and subtraction and the logic operations are AND, OR. The input – output devices are called the peripherals.

The central processing unit on a single chip is called the microprocessor. The arithmetic and logic unit is carrying out the operations such as addition, subtraction and the logic

operations are the AND, OR operations. The register array is having a set of registers which are acting as temporary storage devices.

Whatever the information is obtained from the memory may be permanent or the random access memory. These information will be stored in a temporary manner inside the CPU itself. Based on the control instructions the microprocessor is taking this information which is at the temporary storage. It carries out the arithmetic and logic operations on this information, which is stored in the register arrays and it further give the output which is stored in the register array itself.

Whatever the results are stored in the register array will be taken through the bus that will be communicated to the output terminal if required or it will be stored inside the memory. The control unit is carrying out the function of controlling the signals or the data to fetch the data through the system bus and apply the set of instructions over the data by the control unit.

The timings will be set. It has a clock. It is nothing but, an oscillator. Oscillator circuit is the piezoelectric based clocks. The clocks are giving signals like the time is over, now the next set of instruction is to be executed. Accordingly the processor will take the data and process the data and return it back to the register array.

The peripherals are nothing but, the keyboards or the ADCs i.e. Analog to Digital Converters. The analog to digital converters are converting the analog data into digital format, and that digital format data will be given to the microprocessor to be used for the embedded operations.

But, if the microprocessor is a part of a microcomputer then the data is input through the keyboard. If the microprocessor is utilized in a microcontroller, then the output would be given to the actuating device through the signal condition device such as DAC i.e. a Digital to Analog Converter. But, if it is a microcomputer, then the output would be simple display devices such as LEDs, CRTs or a printer or a magnetic tape.

There are two types of memories which are used, that is a read only memory and the random access memory. In read only memory the programs which cannot be altered are stored. These are the system programs which the user cannot change. Some programs

like the monitor program or the drivers of the hardware are stored in the read only memory.

The data on the random access memory can easily be changed. Here we are giving the data that is to be processed or the programs which is to be modified or edited. Bus is nothing but, a group of wires which are used to communicate the signals among the various elements of the microprocessor system.

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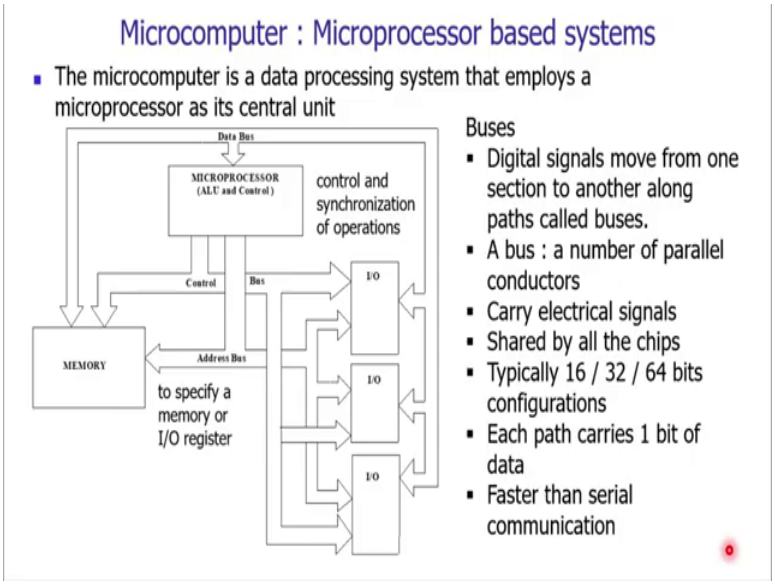

After studying the definition of a microprocessor, microcomputer; now, let us look at the configuration of the microcomputer. A typical arrangement of a variety of elements of a microcomputer is shown. It has the ALU and control unit. It has the input – output devices. These are the peripherals, the memory and various types of buses. These buses are carrying the digital signals from one section to another section.

These are the paths through which either the data related to the variable, the instructions of carrying out the controlling operation or to communicate the address of the data are communicated. The bus is nothing but, collection of a number of parallel conductors. These are carrying electrical signals and these buses are being shared by many chips which are integrated in a typical microcomputer.

There are various configurations of microcomputer based upon the number of bits. We can call a 16-bits configuration or 32-bits configuration or 64-bits configuration.

The meaning is that, we can handle 2 raised to power number of bits values by using these communication paths. If the number of bits are 16 that means, we can handle 2 raised to power 16 types of values by using this communication path. As the number of paths are more, faster communication can be obtained.

In earlier days, there was a serial communication in the microprocessor, the information or the instructions was passed in a sequential manner. This is why the microprocessors were very slow with the invention, however with the introduction of the parallel communication by using these wires, now the microprocessors are very fast and rapid with each path carrying 1-bit of data.

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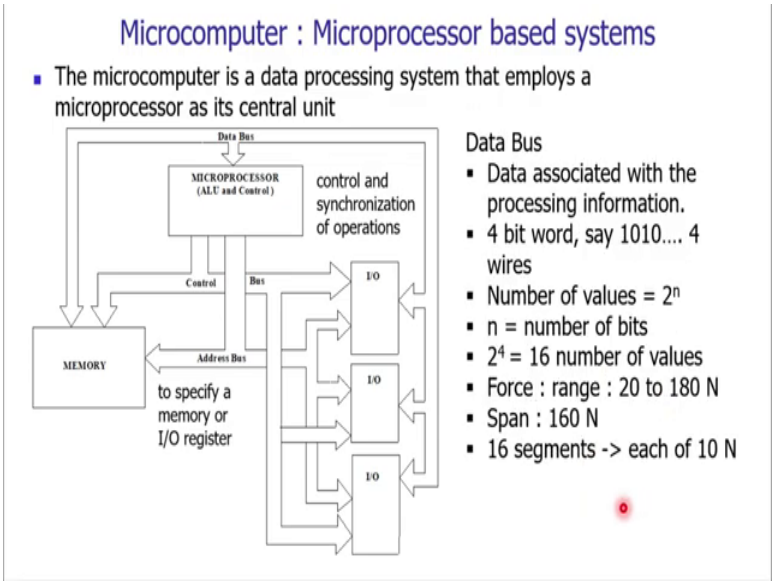

There are basically three types of buses being used in microprocessor or a microcomputer. The first type of bus is the data bus. The data bus is associated with processing of the information.

If there is a word length of 4 bits consider a word of 1010; that means, we require 4 parallel wires that to be laid down to communicate this word 1010. The number of values which are possible by using this 4 bit data bus; so, we can have 2^4 i.e. 16 number of values can be handled by this data bus.

An example can be considered of an embedded system which is used to record forces and to process the information about the forces say, automatic way balance machine.

When the force is in between 20 to 180 Newton we are using this device, this is the range of the device i.e. 20 to 180 Newton capacity. The span would be 160. As the number of values are only 16, so we can have only 16 segments of the span. The 16 segments of the span can be handled by this microprocessor or the embedded system.

Each segment may have a 10 Newton of the capacity. The 4 bits type of data buses or 4 bits type of the communication systems are quite often used in toys. Automatic toys need to process very small variety of information , but the general computers used nowadays have the capacity of 64 bit maybe more than that.

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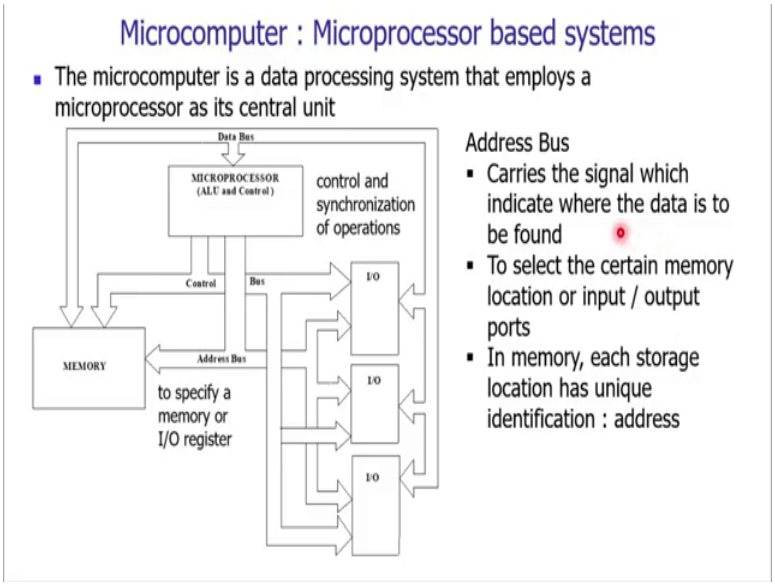

The next bus is the address bus, it carries the signal which is indicating where the data is to be find out. It carries the locationand the information about the location of the data from which we have to fetch or load the data or write the data in the memory locations.

To select certain memory location at the input or output ports as well, it is not only getting the data from the memory locations at the memory. In the memory, each storage location has a unique identification which is called the address.

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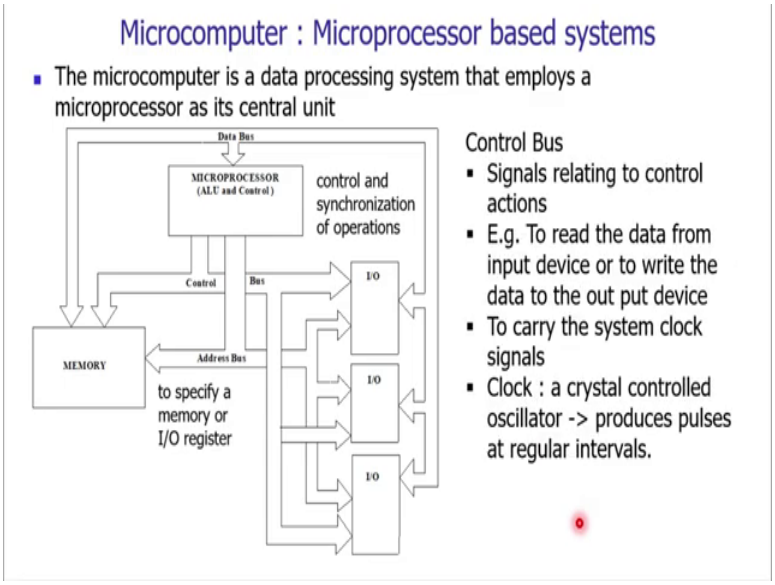

The next type of bus is the control bus. The control bus is carrying out the signals related to the control actions. We are reading the data from the input device, it is basically the function of the microprocessor to read the data. It is controlling this operation of writing the data to the output device.

And, this controlling operations would be carried out based upon a clock. The clock is nothing but, a crystal controlled oscillator. It produces pulses at regular intervals and based upon the clock signals, the control bus operations would be carried out by the microprocessor.

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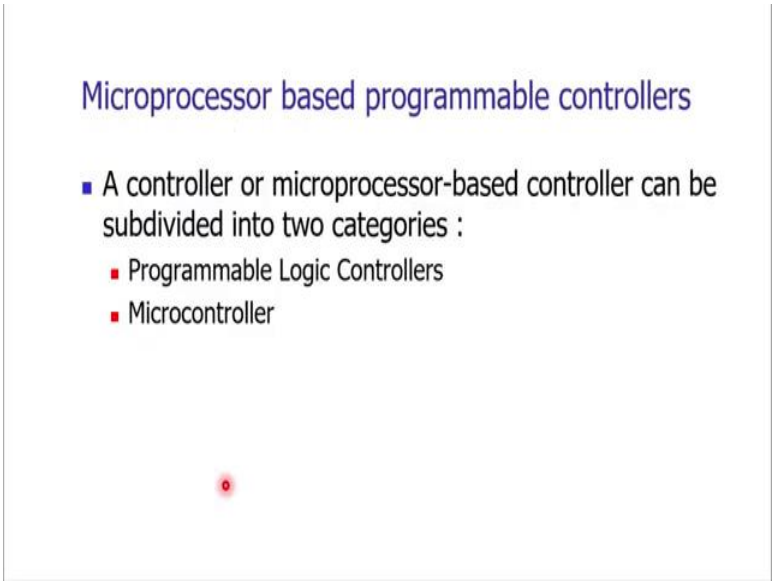

What are the various programmable controllers which are based upon the microprocessor. In the industry, basically PLCs i.e. a Programmable Logic Controllers and the microcontrollers are often being used, these two devices are incorporating microprocessor as their CPU, Central Processing Unit.

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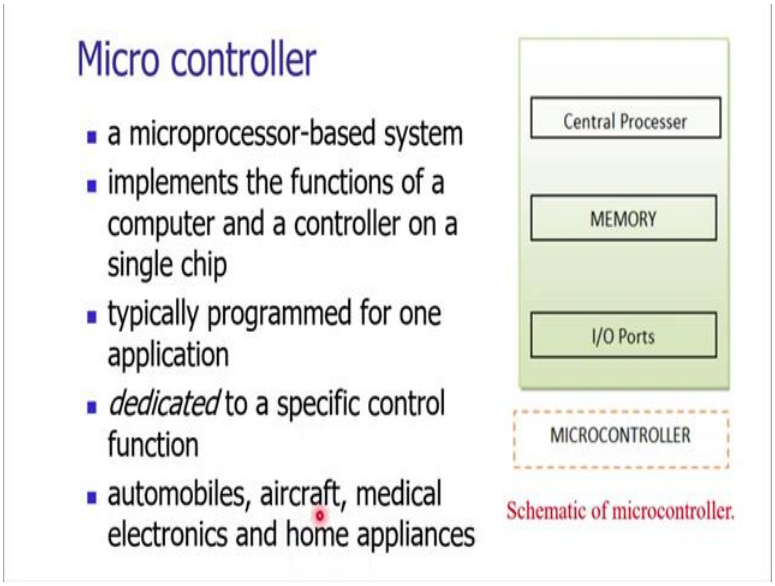

The microcontroller has the central processor, the memory and the input output ports. Together it is called as the microcontroller. It is implementing the functions of a computer and the controller, but all these functions and all this circuitry is on a single

chip which is the uniqueness of the microcontroller. It is a very small device which can easily embed inside the equipment itself. All the processing circuitry, memory and input output ports are manufactured integrated on a single chip itself.

But, the capability of microcontroller is limited. It is generally programmed to carry out a few applications and operations; a simple operation say control of temperature in an electrical furnace. A simple operation is to control the temperature if the set temperature is more than then cut it off. For one or two applications, the microcontrollers are used. To control the operations of washing machines, which is having the limited capability, we cannot change its program. It is dedicated to specific control function. Generally microcontrollers are used in automobiles, aircrafts and medical electronics, and majorly they are being used in the home automation, home appliances.

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They are very small and can be embedded in a electromechanical system without taking up much space. They are space effective, very small integrated compact devices. They need very little programmable memory. Memory required is also very less. Some of the standard microcontrollers available in the market are Motorola 68HC11, Zilog Z8, Intel MCS 51 and 96 series.

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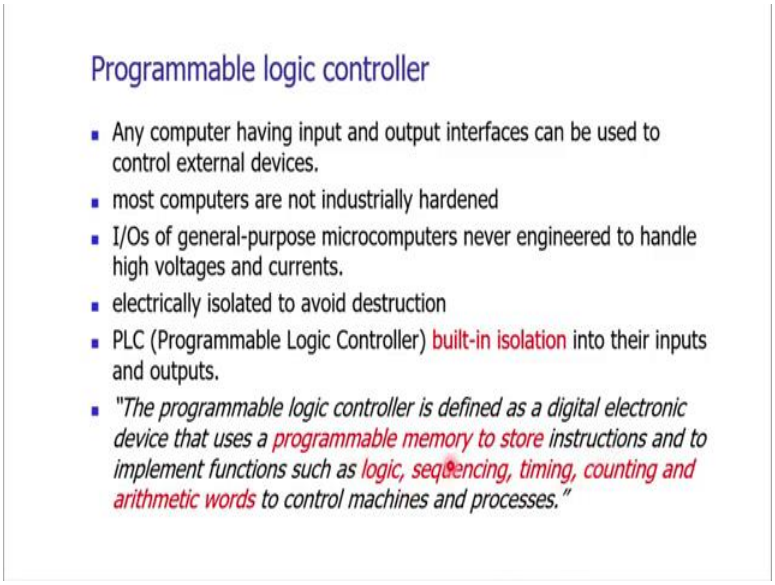

The next type of controller is the programmable logic controller and it is often used in the heavy industry, heavy automation industry. Any computer which is having the input – output interface and can be used to communicate with the external devices is nothing but, a programmable logic controller. The difference of a typical PLC with the micro controller or microcomputer is that, the computers or controllers are not industrially hardened.

They are not designed to sustain in the harsh conditions in the industry. Harsh conditions may be very high currents, high voltages, high temperature, high humidity, high noise, vibrations. Microcomputers may not sustain this harsh environment. The spatial microprocessor based device which will sustain all these harsh conditions is nothing but, the programmable logic controller.

The PLCs have electrically isolation circuitry. One very important isolation circuitry is an optical isolator or opto isolator. These type of isolation circuitries are integrated in the PLC to safeguard the circuitry of the PLC from the harmful signals.

The PLC is a digital electronic device, it uses the programmable memory to store the instructions and to implement the functions such as logic, sequencing, timing, counting and arithmetic words to control the machines and processes.

These functions are very general. They are there in the microprocessor, in microcomputer and in microcontroller as well, but when we use these technology especially to control the machines and the processes, then that device is called as the programmable logic controller.

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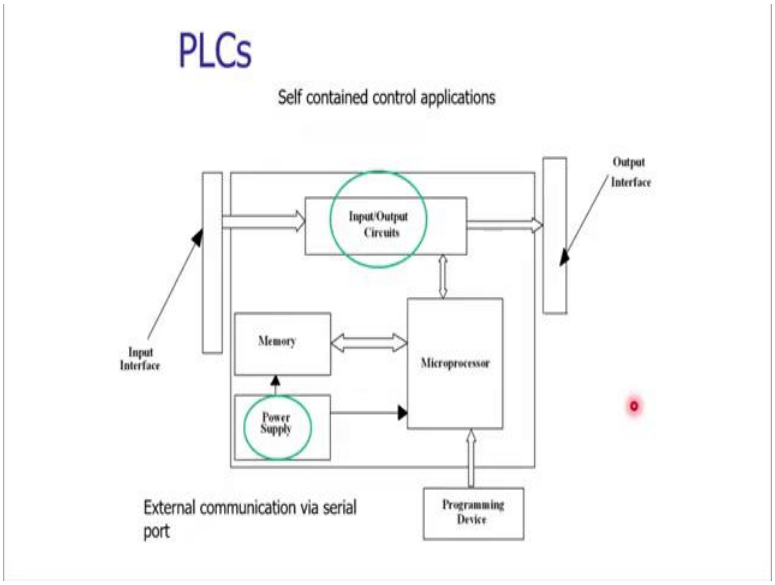

A schematic of the arrangement of various elements of PLC can be seen. Here, the PLC has all the typical elements which are there in a microcomputer. It has microprocessor, communication ports, communication paths that are buses, memory.

But, the PLCs have a power supply that is supporting and assisting the memory and the microprocessor. It has inbuilt power supply which is helping the memory and microprocessor to survive. The PLCs have the input – output circuits and dedicated input and industrially hardened output interfaces, so that the circuitry of the PLC will be safeguarded.

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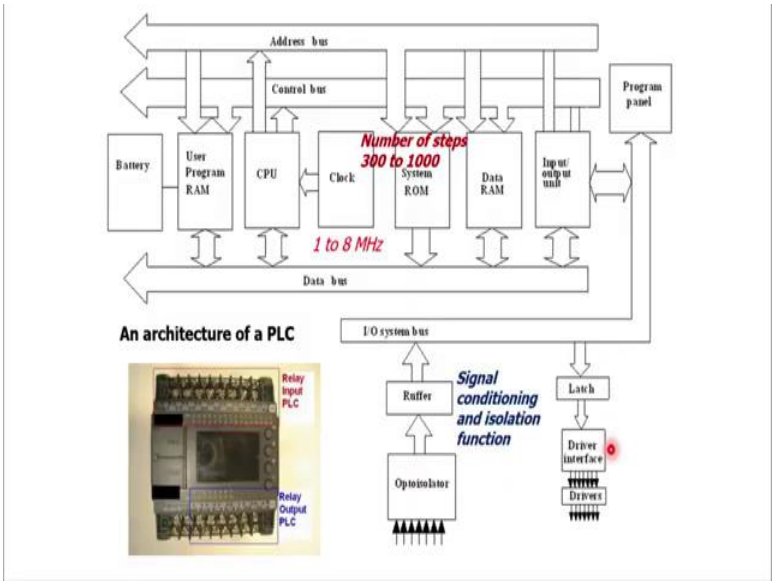

Little more details about the PLCs can be seen on the screen. It has all the elements of a typical microprocessor based system that is CPU, the clock which is controlling the operations of the CPU, the memory elements such as the read only memory, random access memory, input – output units, various buses, input system address, bus system and the control bus system. It has the battery which is supporting the memory, the user program memory here.

The opto isolators are used in the PLC system. Opto isolators are protecting the PLC from very harsh signals. The input output system is having a buffer and the buffer is attached to the opto isolator system.

If the signals are in acceptable range they will be buffered in a buffer register and then the through input output system bus will be communicated inside the circuitry. A typical PLC can be seen. It has the output relay and input relay, output terminals and input terminals.

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Few more pictures of the PLCs can be seen. This is the Mitsubishi FX1S-20MR, the construction of the PLC is very rugged and robust; only the interfaces are open to the external world and the construction is very compact and strong. Many PLCs can be collected together and they can be stored in a rack with multiple number of PLCs that are stationed.

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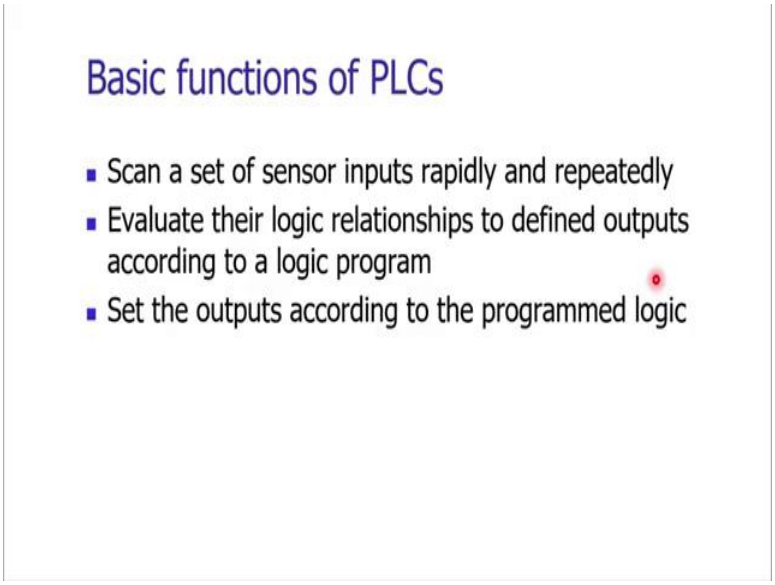

Let us summarize the basic functions of the PLCs. The PLC is scanning a set of sensor inputs very rapidly and repetitively. They are getting the inputs at a very fast rate and

then they evaluate that sensor input and carry out the logic operations on that, and according to the program written they are generating the output.

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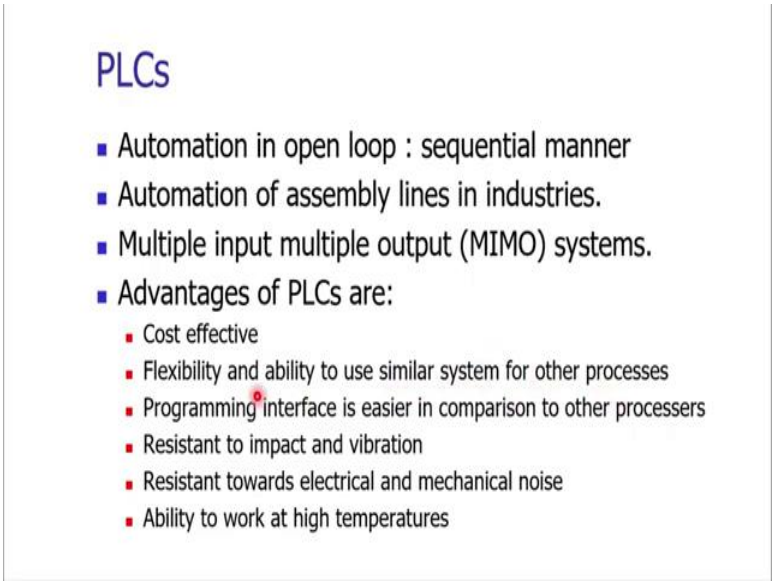

PLCs are used in automation in open loop in a sequential manner. They are also used in the assembly lines in the industry. The PLCs have multiple inputs and they do have the multiple outputs. The same PLC can be connected to many equipment with multiple inputs and can be taken inside and the output can be given to the actuators or the actuation devices.

What are the various advantages of PLCs? The PLC is a very cost effective, flexible and it has ability to use similar system for other processes. The PLC is not a very dedicated or a special purpose device, it is a general purpose device. It is having multiple inputs and multiple output, the same PLC device can be utilized for the other processes provided we have to program it accordingly.

It has the capability to resist the impact and vibrations. It has very good resistance towards electrical and mechanical noise and it can be used in very high temperature. This is why they are very popularand important in the automation industry.

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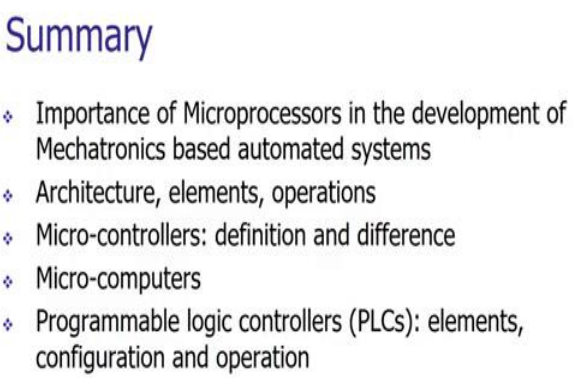

We have seen the important building block of a typical mechatronics based automated system is microprocessor. We have seen its importance. The microprocessor is the brain of the automated system. We studied the architecture of a microprocessor. We have seen its elements, various modules, the operations of these modules and elements have been studied.

After that we learnt about the microcontroller. The microcontroller, its definition and its difference with the concept of the microprocessor. Then, we have also seen the microcomputers its meaning and finally, we studied the PLCs that is Programmable Logic Controllers, its elements, configuration and operation.

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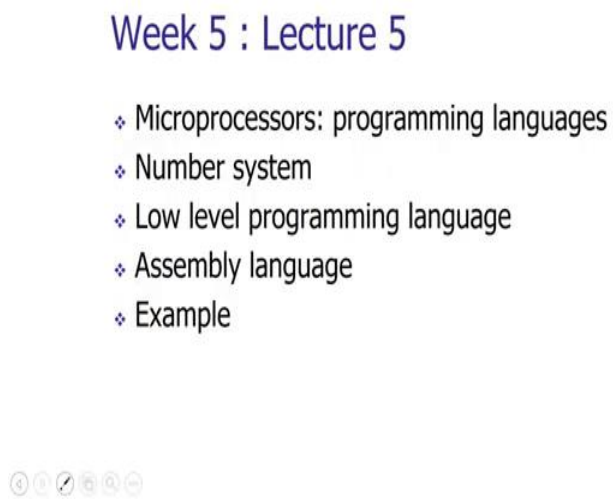

In lecture 5 of week 5, we will go ahead with programming languages which are used in designing of microprocessors. We will have an introduction to the programming languages, the number system, what is the meaning of low level programming language, what is the meaning of assembly language and in association with that we will have an example. We will have a case study.