Industrial Automation and Control
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Lecture - 22
PLC Hardware environment
Components
Architecture
Functionality

Welcome to lesson 22, so far we have learnt about the basic functioning of a PLC, we have learnt how to write a program for it, but all these time we have seen the PLC as an abstract device, we have not seen what is inside a PLC system, what actually physically makes it. So, in this lesson we are going to look at the hardware environment of the PLC's, basically what PLC systems are made of. So, we are going to look at components, we are going to look at components of the PLC system, their architecture where which I mean that, how they are organized, how they are connected and their functionality, that is describing what they do?

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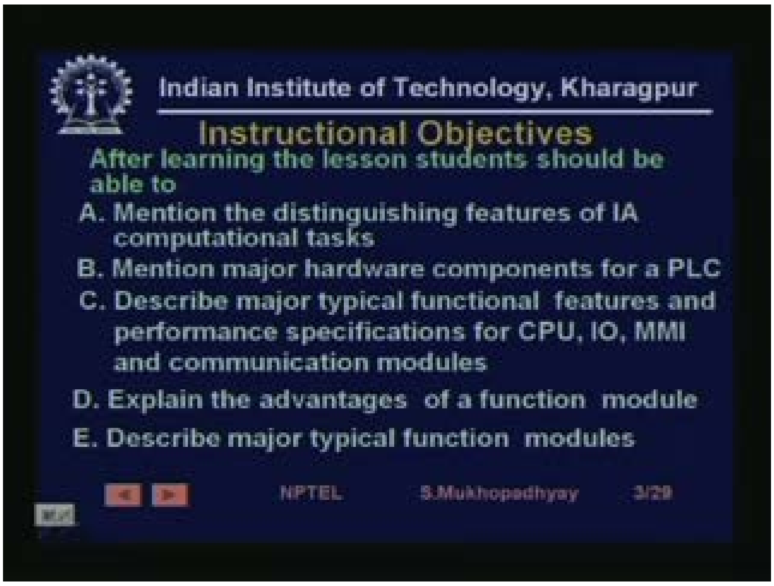

So, let us see before we begin it is customary to see the instructional objectives, so the instructional objectives are the following. First after going through this lesson, one should be able to mention the distinguishing features of industrial automation computational task a PLC basically is a computer. So, it performs computational tasks related to industrial automation, but this task have certain very distinguishing features compared to the other tasks, which are let us say done in an office environment.

So, we are going to you should be able to mention some of these features, mention major hardware components of PLC, describe major typical functional features and performance specifications for the CPU, Central Processing Unit, I/O or Input Output MMI, the Man Machine Interface and communication modules. Then, explain the advantages of a function module, so what are the advantages of a function module, which you will be able to explain and describe some major typical function module types, so these are the instructional objectives.

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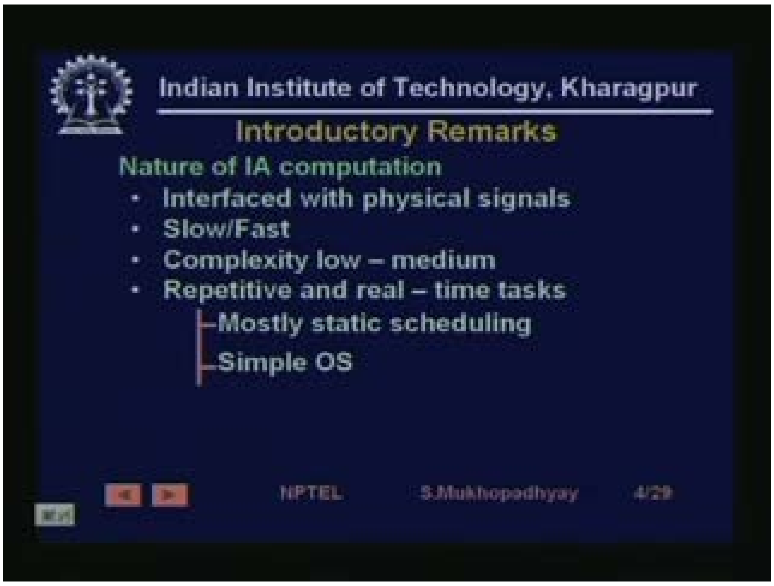

So, let us start with the industrial automation tasks and their distinguishing features,so we are going to look at the nature industrial automation, what I call IA computation that is computation related to Industrial Automation. These kinds of computations remember that are always working on physical signals, so there are temperatures and pressures and limits which positions, starter positions, etcetera which are all very physical signals electrical in nature.

Which are interfaced with the PLC and PLC looks at it values and take this some of these are inputs and computes the output, which it computes according to some it is software for example, relay ladder logic programs. These, tasks requirements are I mean by standards of other applications using computers, let us say digital communication or personal computing, these tasks are the computational requirement of these tasks are generally called slow or generally I mean should be slow.

Although among themselves there could be task, which are very slow for example, temperature control task a very slow having time constraints of the order of the minutes. Let us say flow control tasks would be faster and if you have a machine control or you know you have to have a an actuator control, electromechanical control actions. So, in such cases the tasks are relatively faster, but even those you know basically they are all made of to move an electromechanical system with a certain finite amount of power.

Generally requires times of the order of milliseconds or utmost a fracture of a millisecond, before that no perceptible motion will be produced. On the other hand, these feeds are much slower compare to the speed of electronics, which we typically encounter and let us say communication systems. So, in that sense they are slow, although within their own categories there can be fast tasks and slow or medium fast task or even slow tasks. So, that is why I wanted to mean when I wrote slow fast.

The complexity of this tasks are also not very complex, some they are very simple relay ladder logic diagrams are often very simple. But, there could be other complicated control algorithm, there could be self tuning algorithms, which could be somewhat complicated. So, I would say that the complexities of these tasks are you know low to medium, not highly complex, interestingly many of these tasks are repetitive. For example, if you take a standard process loop, then every sampling time you have to input the control variable and based on your control law, sense the set point and then compute the manipulated variable.

So, this computation of the manipulated variable and inputting the set point and the control variable goes on repetitively. So, these are generally repetitive task and the real time any computational task is called real time, when there is an explicit time boundary by which this task should be completed. And this fact is actually taken into the design of the computational systems, which is suppose to perform this task.

For example, in a control loop whatever computation you are having that should be completed within a sampling time. So, there is an associated deadline for completing this task once they start it, so you in other words even if you have a very grand control algorithm, which takes a lot of time and does not complete within a sampling time is not at all suitable. Rather, probably a less grand controls scheme, which we complete within the sampling time will be preferable.

So, in that sense they are real time and for real time tasks one has to because, you know you have also realize that within one PLC, there will be several control loops working either runs, either they are discrete sequential control or they are analog controls whatever it is, there are a number of control laws which have to be repetitively executed. So, there is a requirement of determining that which should be run at what time because, some of them will have to be run, let us say every 20 millisecond, some of them may have to be run every 500 millisecond, some of them may have to be run every 2 minutes.

So, this is called scheduling, so there has to be a mechanism of scheduling tasks at the appropriate time. So, that computational resources are utilized and all the tasks are finished at their before their deadlines, so this is generally done using technological scheduling and will not go much into that is in the domain of real times systems. But, generally in the case of PLC's even when there are PLC scheduling are generally very simple and they are static, in the sense that they are the strategy which is adopted is fixed, it does not change according to situations generally.

Similarly, if they have very rudimentary kind of operating systems generally much less sophisticated, than standard other operating systems like, UNIX. Apart from that, but one thing is very interesting that when you have a PLC, I mean these computational tasks are very mission critical in nature in the sense that we do not want to have any kind of errors in them. So, these should have very good reliability and they should ensure always ensure, worst case performance specifications we cannot check average case performance specifications.

Like for example, you know if you have Ethernet, then we know that Ethernet worst case performance is generally very I mean goes down significantly compare to it is average case performances. So, but here whatever technology we are using we should generally always use worst case performance as the performance guarantee. Because, the consequences of task failure could be very great, lastly often it happens that this computational task have to be performed at very you know harsh, physical environments, environments having lot of dust, heat, moisture, vibrations and such things.

So, the hardware has to be such that it is not affected by these one has to device a you know proper sealing's, one has to device proper cooling mechanisms, these are also very important in the case of industrial automation computer systems to ensure that the tasks are performed reliably and as expected.

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So, having said that let us look at what makes PLC, so as I have said that a PLC is basically a microprocessor based system. So, as we know that a microprocessor based system will have the major components are number 1 CPU, number 2 memory, number 3 input output, number 4 power and number 5 the buses. So, here also you will find basically the same things, so here you have the CPU, this is the CPU and here is the memory, as we will see memory can be of various types.

And you will find you can easily make out, that the PLC applications are very rich in I/O because, their basic job is to interact with the physical world, so there. So, you have various kinds of I/O for example, you have analog I/O, you have digital I/O, you have remote or sometimes called distributed I/O, you also have network communication much of it is again I/O. So, you have various kinds of I/O, you have man machining interface which is also kind of I/O input output.

Then, you have a programmer by which you can develop a program, let us say an RLL program and you can load it into the PLC memory, that is also kind of I/O. Then, you have power, you have the back plate that this is the bus which connects the various PLC elements. Sometimes, you have you must be knowing that sometimes you have you know other processors, which assists the main processor, so you could have a this is not common this is wrong, what I meant to write is a communication processor.

So, please correct this by which I wanted to mean, that this is the communication processor you know because, it has to a PLC is has to sometimes communicate with special purpose device. So, it is that job is often given to a separate processor, similarly it could have separate input output processor, it could even have network processor, in fact communication processor part of the job is to do communication, may be on the network environment also.

Sometimes, you have separate these are actually I/O which are intelligent, in the sense that they have their own computing capabilities. So, one needs to, so the main CPU needs to talk to it, so therefore, this is also a kind of I/O, so you see that a PLC is basically a microprocessor based system with a lot of I/O and we are going to see what these different types of I/Os are...

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So, let us look at these modules at some level of depth now, so you have a typical processor would be I mean this is just an example, it could be 80186, it could also be from the 68,000 line various choices are available, sometimes these processors are you know proprietary not standard processors. Along with the standard processor as I said you could have co-processors, for specific purposes like I/O, like handling the programming input etcetera or managing the network you; obviously, have RAM, RAM is required for running.

You have sometimes, you have dual ported RAM dual ported RAM is RAM in which simultaneously one it has two ports. So, it can be simultaneously written into an read from, this is important especially when you want to read data from devices, which are working without really stopping the device operation, you want to read data or you want to write data. So, you can on the fly parameterized dump some new parameters for a PLC, while the PLC is working.

So, the PLC continuously uses memory, but in between when during those brief instance when it is not using the memory, if you have dual ported RAM, then using another processors you could write the same memory. And you know download your parameter values in the meantime into the memory, which the PLC will use as it gets them. So, this kind of you know reading and writing on the fly by another processor is possibly, if you dual ported RAM.

You have EPROM or E square EPROM these are typically, you know read only memories and they are used for storing the PLC programs. You have programmer ports, which are used for downloading programs, you have network ports, you have backup battery, this is very important. Because, by any chance if you have power failure you do not want number 1 your process state to be lost, number 2 you do not want to lose your parameters, so there is a backup battery always which will backup part of the RAM. And you obviously need the power supply which could be internal within the processor module or it could be external has a separate power module, which will connect to the processor module, it could be either way.

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So, let us look at a typical PLC system a picture which will clarify the things, so here is a typical PLC system. So, you can see that it contains multiple CPU units, actually you know these are, if you look at them that these are the see various CPU units, so these are the CPU units. Some of them could be communication processors or other co-processors, one of them will be the main processor, there are a number of rack mounted I/O modules.

So, these are rack mounted I/O modules, I/O racks each one of them will plug in one particular I/O card, which will have various which will interface a number of I/O signals. And you have the power supply here, so this is how it typically looks you know you can see a number of ports. For example, you have a number of ports here, so these are probably the communication processors we cannot because, they are having, so many you know RS 232 ports, serial ports look like some there are some parallel ports looks like printer ports. So, this is how a PLC actually looks like, there are actually this is not the only type PLC systems could be very large, they could be very small everything comes into one box that is also possible, this is medium range kind of application.

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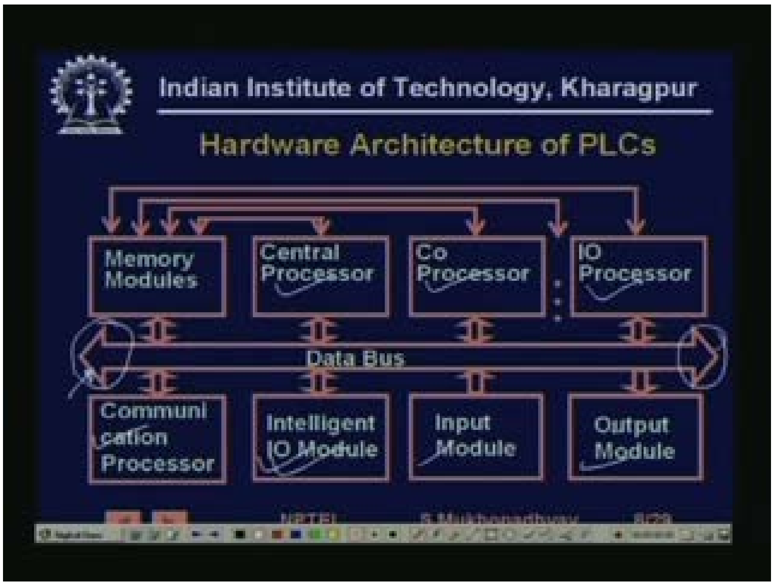

So, having looked at that let us see the how these various things are schematically connected, we just saw a diagram. So, you see that this is the scheme in which these various processors and the modules are connected, they are all connected by a bus, this is… And obviously, as we have seen that various I/O modules are mounted in rack. So, there will be a ribbon cable like thing, there will be a flat cable which will act as a this bus, you know it will connect the various modules.

And sometimes these modules can even may not be situated at the on the same row, sometimes they will be connected one after the other, sometimes they may be connected in a cabinet which is a little distance away. So, this bus really has to extend sometimes using cables also, so you have central processor, various kind of co-processors, I/O processors, you know now a days we are having the age of you know embedded processors. So, some of these processors are use even DSP's, so there could be numeric co-processors or I/O processors.

Generally, there are communication processors for specific communication to you know kinds of device a, like operator stations or for communication on the network, there are various kinds of I/O modules some of them have processors on them. So, they are called intelligent I/O some of them you know ordinary I/O which just takes signals and feeds into the central processor plus there are; obviously, memories. So, this is the basic hardware architecture, which is very common for microprocessor based system, they are generally organized around the bus oops.

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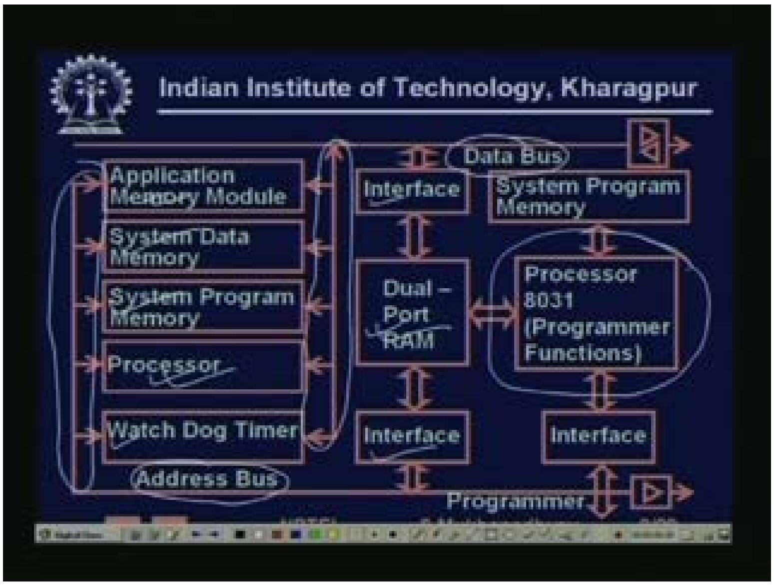

And if you see inside one processor that's also pretty standard, in the sense that you know you have as you all know, that also microprocessor based systems are have two kinds of buses, one kind of buses called data bus and another kind of bus is called an address bus. So, using address buses we can talk to specific devices and then we can exchange data over the data buses, so you know these are the data buses connects to various devices.

And these are the address buses by which the devices can be selected, you have the main processor, you have various kinds of memory, you have application memory, where the computational task run even for running task you need a for managing the resources of the PLC you need some, you know programs which are typically called systems programs. So, for that you need system program memory, you need systems data memory, you have you know special kinds of PLC systems are you know just like your you must have experienced that sometimes you are your PC hangs, it just sits quite doing nothing somehow it gets ((Refer Time: 22:55)) into some you know infinite kind of loop.

So, this is prohibited in PLC systems if due to from reasons like, wrong programming to memory correction, if the processor gets is stops doing useful work. Then, there has to be explicit mechanism mean by which the processor execution must be broad out of it and taken into a safe state. So, this typically done, but watch dog timers which are hardware devices and sometimes there also I mean, they are actually hardware devices and if these timers find no proper activity, over certain periods of time then they by force take the processor to some safe state.

So, you could have you know dual ported RAM's as I said apart from the normal RAM's; obviously, there has to be various kinds of interfaces. Sometimes, you know here they have shown here we are seeing a particular another additional processors, see this is the main processor. But, we are seeing an additional processor and the job of this processor is to interface with the programmer, so that you can while this system is working you know a PLC system is typically interface with the machine and industrial machines often run continuously.

So, you must provide mechanisms, so that you are able load new parameters, reads status you are able to work with the system, while the system is working with the machine. So, without stopping it, so for that since not only unit a dual ported RAM, you need another processor which will talk to the programmer, while the main processor is actually busy controlling the machine, so this is what is done.

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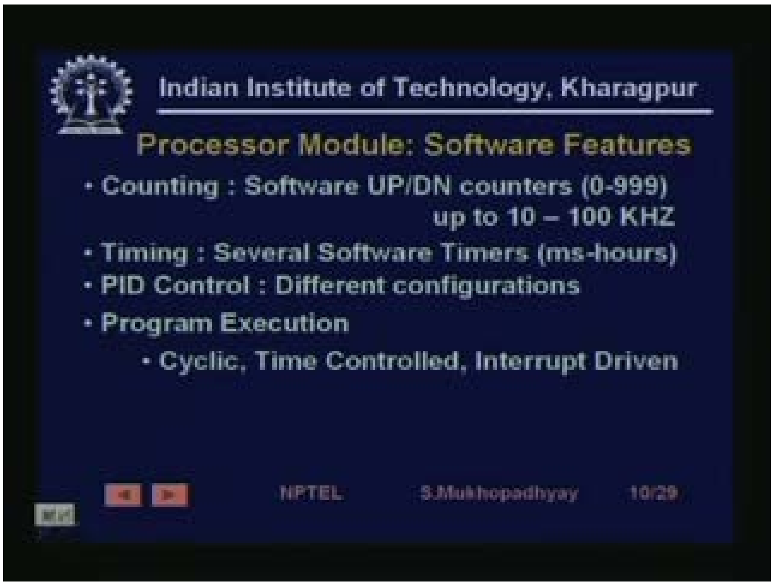

So, typically these processor modules though this is mainly a discussion on a hardware, we would like to mention that this typically this processor modules come with some pre programmed software, minimal preprogrammed software more than that you one has to develop or one has to take from additional libraries. So, you have some standard things are supported like for example, basic counting timing functions, some software up down counters quite a few of them actually from 0 to 999 typically I mean the typical value. And several timers of which can time duration of the order of milliseconds, two of the order of several, several hours are even sometimes days are available, you have various you know standard control algorithms already pre coded, so that the users do not have to can easily configure their systems.

The program execution in these systems is very interesting, there are generally three four different types of program execution mode specified. For example, a mode could be cyclic by cyclic we mean that you have a number of computational tasks begin just like RLL program execution. So, begin here come to the end start all over again, so this just goes on typically cyclic time remains more or less constant, but it could vary little bit depending on the program logic.

For example, if you have some program control statements if then else kind of statements, then whether some blocks will be executed or not will actually depend on the data. So, program execution time is not always constant it actually depends on data, but roughly it will be constant and in fact, it is preferable that it is constant. So, that you are surprise that for some value of data, suddenly your program execution takes a very long time and your deadlines are missed.

So, it is preferred that real time programs have predictable and not too much varying time requirements. So, for many classes of applications cyclic is good enough, so that is a simplest apart from that you could have a time controlled executions, where certain operations will start after certain times, either absolute times or relative times that is start the pump after 30 seconds of opening the valve, this kind of controls can be executed.

So, exactly 30 seconds after, so this execution is timer controlled or time controlled or it could be interrupt driven , there are some tasks which can suddenly occur, like you know failures kind of tasks, which once they occur they are not taken into the consideration of the regular computing flow. But, once they occur they are require to have very high priority and therefore, they have to immediately get the attention of the processor.

So, such tasks are sometimes coded in the interrupt driven execution mode, so whatever the processor was doing it will be interrupted and this requirement will be get into. So, but all certain done for a given, I mean typically one must understand that typically a PLC has much less computational capability compare to a PC. Although it is generally a much more expensive or that is if you take PLC's and PC's of the same kind of price, then you would find that the PLC is much, much less computationally capable compared to I mean a normal PC, which sells in the market both in terms of memory and in terms of computing speeds.

That is because, you know price of things get actually decided by the sales volume plus the PLC has certain other feature they are actually very ragged and there are different kind of packaging. So, all these things make this and the third reason is that a PLC is not general purpose computer, so I mean no one is going to download, nice files from the Internet and store it there and then your E-mails keep piling up, such things do not happen.

So, therefore, memory requirements are generally well understood and much less than what is required. So, therefore, they are one keeps things only which is required because, one wants to make things reliable and putting too many things into machine makes it unreliable. So, but one has to understand that these are although they are much like PC's in fact, there are in the market the competitors of PLC are actually industrial PC's, which are early PC's run on I mean known as similar operating systems, windows or some versions of it, but they are actually they have generally much lower computations capabilities.

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So, we have then we look at input modules, input modules basically convert process level signals to processor levels. So, what do you mean by process level signals, process level signals are signals which actually exists on the field. For example, they could be 24 volt DC signals or 230 volt AC signals or even sometimes contacts sometimes RTD platinum RTD or could be a 4 to 20 milli Ampere current loop, the signals which actually come out of sensors, a sensors and actuator the devices.

So, these a PLC is an electronic device it circulate digital electronic device, so you it as such cannot take in that kind of electrical signals. So, it must convert them to processor level signals, which are digital typically 5 volt or may be 2.5 volt whatever, so that job is actually done by the input modules. So, their job is to basically translate process level signals to processor level signals, also convert them from analog to digital sometimes, if they are not always digital.

So, the jobs are mainly another important thing is to provide isolation because, the electronics if you expose digital electronics volt, 215 volt or 230 volt AC directly chances are that will get damaged. So, you have to provide electrical or galvanic isolation using opto couplers, so input modules very often provide that, they provide fault indication. Suppose of war has broken often they provide fault indication, this is a apart from converting process level signals to processor level signals.

They are generally of two types, they are either analog inputs or digital inputs we understand the difference between them. So, for example, a contact would be a digital input and platinum RTD would be an analog input, so obviously, for analog input modules we need to have analog to digital conversion. Typically 12 bits accuracy, multi channel sometimes, one input module generally supports several physical one input module support several input channels. So, they are since each digital channel actually takes one bit, while each analog channel could take as much as 8 or 12 bits.

So, therefore, typically an input module will support you know 32, 64, 128, kind of digital input channels, but it will support 8, 16 or 32 analog channel these are just some typical values. Similarly, sometimes it takes special inputs like you can connect directly connect thermocouples, you can directly connect RTD's, so inputs can be as in the form of voltage, current, resistance, etcetera. Sometimes it can be is a form of pulses for example, a shaft angle encoder can be sometimes connected, so this is the nature of input modules.

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Then, we have output modules, they do the reverse, they translate processor level signals to process level signals, they are output devices and these process level signals, then go to things like motors, solenoid lamps, valves we have to actually do work. So, they have to be converted in form generally they have to made sometimes mostly they have to make be made analog or sometimes even on off kind of signals, but they have to be increase in power because, their suppose to do work.

So, they also provide isolation and for analogs it has to provide the voltage or current voltage and current drive. So, typically a unit that will provide that will be a let us say several amplifier. So, such amplifiers will be put on output modules, for digital output modules you know sometimes they will require high power, you will just give a pulse and you will require that during the duration of the pulse there will be a volt, there will be high current will be switched.

So, that such a thing will be done by the output modules. So, typically let us say using triac or may be an IGBT today one would like to probably use an IGBTs. And they could also be potential free relay contacts, you know that is sometimes we can do suppose we want to switch a voltage or current because, it is digital. So, it has to be on off kind of thing, so you could actually do it in two ways, one way is to use a device electronic device which will interrupt, another is to do a mechanical interrupter, now since these currents can be sometimes very large.

So, therefore, you do not you directly from the output module you do not interrupt a larger load current, you actually use a relay which activates a contactor. So, the contactor is actually a heavy device, heavy contacts you might have seen them and they provide contacts and if you drive a signal into it then some relay will make the contactor work. So, using a low power signal you can interrupt a high current using a contractor and relay, so such outputs can be driven from digital output modules.

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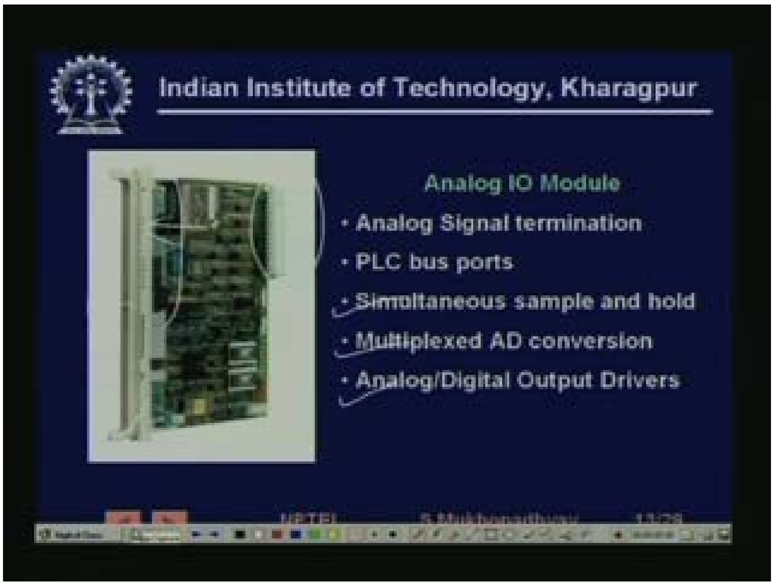

So, let us have a look at some of these pictures for example, this is a typical this is how a typical analog I/O module looks like, let us look that see what it contains. So, for example, you will find that there are some analog signal terminations probably here and there are some bus ports, probably here difficult to see this, inside the you will have you know these typically this is an analog. So, support several channels, so there has to be AD conversion, typically you do not put is not that if you have 16 channels you will require 16 AD converters.

You will take one AD convert and AD converter is, so fast that it will first convert this channel, then this channel, then this channel, then this channel and so on. So, it will multiplex the AD conversion, so you have multiplex AD conversion, at the same time you need to ensure that although you are taking the values one after the other. But, you would like to ensure that the values that you are taking finally, all belong to the same time instant in the process.

So, you use X K, Y K, Z K all of them are at K time instant, so for that you need simultaneous sample and hold, where you take the value simultaneously using sample and hold circuits and you hold them, and then AD converter mix them up. And you also have various output drivers, especially for output modules, so these are basic thing that an analog I/O module will contain. And of course, some logic for synchronization, then you have different kind of I/O modules, which are called distributed or sometimes called remote I/O modules.

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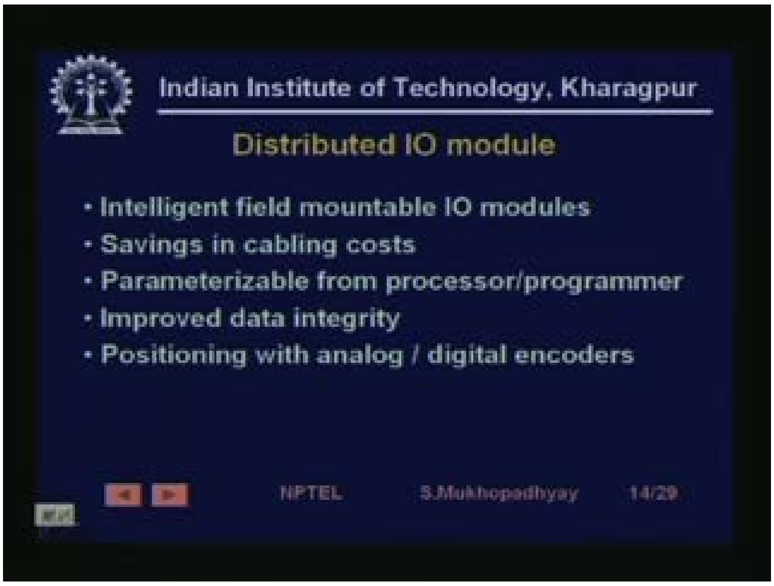

So, these are actually intelligent field mountable I/O devices, so you actually put the I/O module right there are on the machine. And from there you draw a wire or you connect it to a network or you take an input output concentrator and connect several local distributed I/Os and then make one digital communication back to the PLC. The advantages are mainly in savings in cabling cost, I might have mention before that cabling costs are a not insignificant part of any industrial automation project.

So, and they a generally cause inconveniences in industrial environment, they are difficult to maintain sometimes make it cut, etcetera. So, savings in cable costs and maintenance costs are significant, then they are sometimes a and especially when they are on the network, they are actually programmable from a parameterizable from a processor or a programmer. Because, they are they generally communicate with the processor over the first of all they communicate with the processor infrequently because, they are actually intelligent themselves and they can do much of their work.

Secondly, they often communicate with using digital communication protocols, which are much more reliable. So, you have much improved data integrity your cost of cable, etcetera comes down, so typically use for applications like you know very close positioning with analog digital encoders, which requires frequent sampling, frequent slow output generation very difficult to do with a central processor because, it will get loaded.

High speed counters which needs to count high speed events, like you know fast moving, shafts angle pulses. Some specific loop controllers, temperature control loop, etcetera where you just need to download the set points of the central processor and the basic loop works on the distributor I/O modules. So, this main processor is not bothered with that, so that is a distributed I/O generally getting more and more popular now these days.

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Then, you have some other kinds of modules called function modules, these are not sometimes they could also be mounted on the machine and make part of a distributed I/O. But, otherwise they may be situated on the PLC rack itself, but still they are actually independent modules that can execute task independently, so basically reducing the central processor load. So, that it needs to talk to it less often, for precision high speed tasks and they often have their own logic their own pre coded control laws, they have their own you know optimizing abilities it might tune it is own you just have to give it a command that you tune yourself.

So, it has it is own code it will actually tuner control loop and typical application would be stepper servo control, multi axis synchronization, as we have we will see after just following this will going to the manufacturing that CNC machine control. So, where we will find that there are many cases where a precise two dimensional motion has to be created. Suppose, we are actually cutting something along a surface, so you have to create precise two dimensional motion.

So, you have to give motions along two axis motion commands and they have to be very synchronized. So, that is called multi-axis synchronization for such applications, typically you use function modules specialized function modules and sometimes they could be also used with distributed I/O systems to be situated on the machines themselves.

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This is a another controller, which is a valve control module I chose this because, I wanted to show the power transistors on this. So, you can see the power transistors, so it has to drive valve means it can it is probably a hydraulic servo valve or something or, so it has to pull solenoid, create some force. ((Refer Time: 42:27) piston moves. So, for that it needs to provide good amount of current, so these are the power transistor drives, it takes set point from outside. So, it interfaces to the bus and the central processor gives into set point, and it has it is own on board controller, so this is a typical valve.

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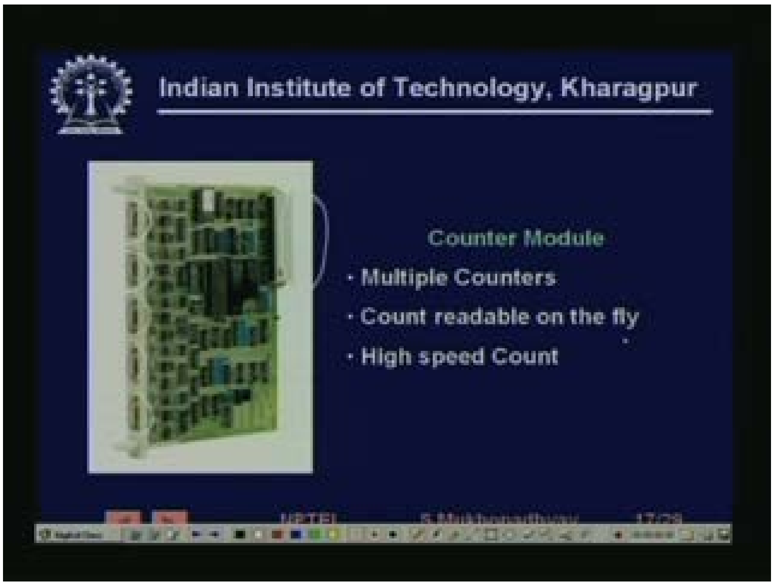

This is another picture a counter module, you cannot make out much from the picture except for the fact, that you can see the certain things you know like for example, ups we need to go back. So, you can see that for example, this module contain something five counters, so you see the count value has to be read on the bus, so these have count values have to be read, then even signals that is up, up, up, up, up this thing has to be come, so there are probably five counters here.

On the other hand it also connects to the bus, so that these signals can be read generally use for, so the count is readable on the fly because, it contains dual ported RAM and high speed count. So, generally use for very high speed counts, so one would have large resistors and things like that, this is counter position decoder see most counter modules can easily be used. Because, position decoding is often by counting the shaft angle pulses, shaft angle encoder pulses that are coming over a certain period of time or because, every pulse will mean a certain small angle rotation.

So, if you want to have shaft angle position decoder it is basically counting pulses, so some of this can be used for either as a counter or as a position decoder. So, you have pulse inputs, you can count or you can read shaft position and both they will be readable on the fly as we said and for high speed. So, this is just you know give you a feel of the PLC system, this is what, this is a position control module.

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So, again position control module onboard dedicated high speed CPU, position control is generally requires very fast computation. So, you have dedicated high speed CPU by high speed CPU means, you have CPU with you know higher capabilities you used higher order processors, when you have low speed controllers, you use you know generally you use things like micro controllers to realize them, while here you could use higher end processor like may be 68,000 and motor drive.

So, on the, so it gives the there is a drive, there is there will be power electronic drive which will be given a set point and the power electronic drive will realize that set point. On the other hand, it will take it is own set point it will take from the central processor, it has digital I/O depending what is the final motor various ((Refer Time: 46:08)) for example, for a stepper motor it is actually driven by digital I/O. So, these are some of these modules which are used in PLC systems, it has a programmer port because, you need to there are large number of parameters which have to be set and set point come from the data bus.

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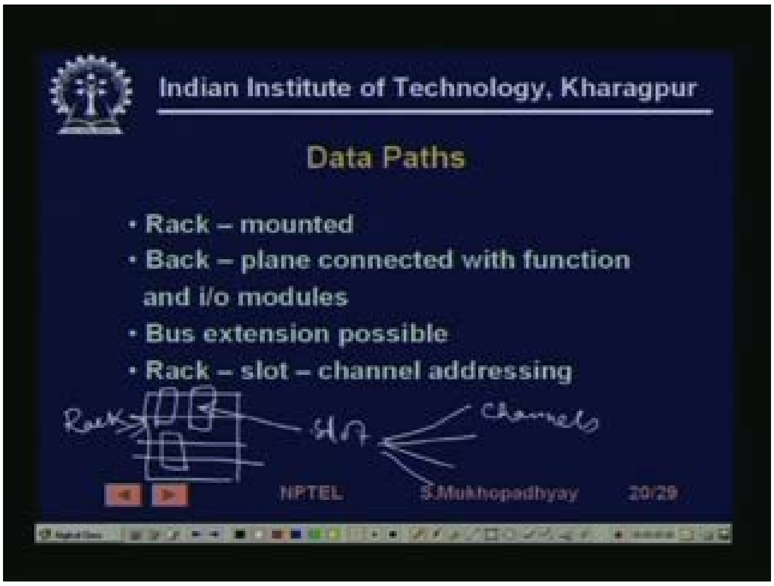

So, all these modules how they are connected that is what are the various data paths to understand this, you have to understand that the PLC, So, the PLC is as we have said that it is rack mounted, so there are number of racks it is like an almirah, there are number of racks in each rack there are slots. So, in each slot you can put I/O modules or you can put CPU modules and in each slot, so this is slot, this is rack and in each slot contains several channels, so there could be 8 analog channels, so channels.

So, this is how I/O is actually organize it is rack slot channel, so if you want to identify a particular physical signal, have to have a rack slot channel addressing which is implemented in various ways by various manufacturers. Now, all these racks must be connected, so they are actually connected at this level by ribbon cables and then from rack to rack connection is generally achieved, we will see which is the next diagram.

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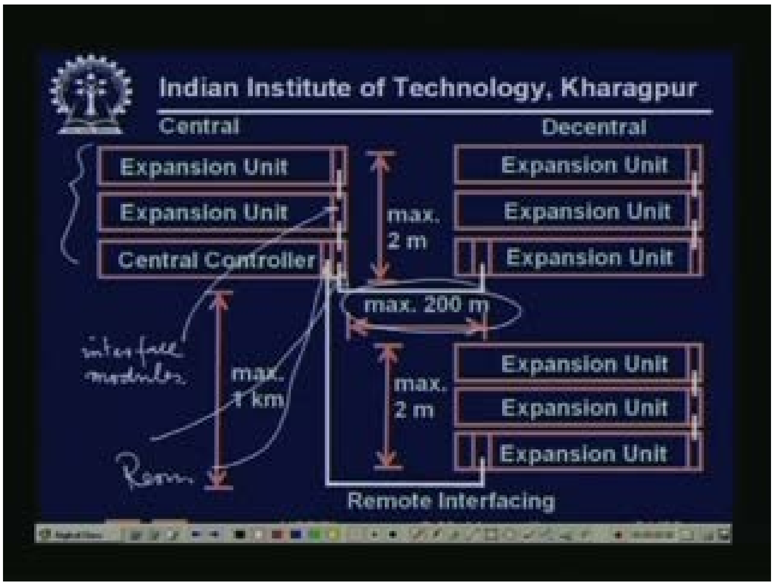

So, here you are, so these are you know this is one rack let us say, this is one rack then you can have several racks. So, they are actually connected by what are known as interface units, so these are interface modules, similarly so you can expand your number of modules, sometimes you can put as I was telling that you can put your modules in a different almirah, which is different cabinet and I say almirah actually it is a cabinet.

So, for that you need to have a special you know special interface unit, so typically an interface unit will it can be say typical ((Refer Time: 48:50)) is such distance for reliable data transmission such distance requirements are there, at a certain rate. So, go you can go up to something like 100 meters which is a lot and sometimes you can have remote interfacing. That is actually you have you may be having your CPU in some that is your basic PLC system in some control room, while you have these various interface units in the various shop floors, which could be even in a half a kilometer away and things like that. So, in for a such cases you need special interface units which are called remote interface units. So, this is the way that all these elements are actually connected with each other and buses are extended.

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Then, all these things that are happing one generally wants to get a view of it, so to get a view of it you use a man machine interface and as such PLC modules often work without any intervention from human. So, as such they have very little you know MMI capability, they do not have generally contain displays by themselves, they will probably contain some LED's which will just indicate whether they are functioning normally or not. But, if you want to visualize if you want to monitor what is happing to the various variables, if you want to trend them show it nicely to an operator it is possible, through the various man machine interface elements.

So, you can have operator panels by which an operator can give command through a variety of devices, some of them may be mobile, they may be it may be push button, joystick, various kinds of you know multi function input panels various kinds of things. Similarly, you can see it you can actually connect a PC to a PLC and on which various kinds of visualization software, which will nicely show your plant and you know as you know I mean levels of fluids will go up and down, it will nicely show you on the screen. So, such visualization software ((Refer Time: 50:57)) PC's can be used for man machined interfaces.

Sometimes, especially in for power applications you have remote terminal units that is basically the system is working. And let us say unmanned stations and from kilometers away you want to get a view of what is happening, let us say which of the transmission lines are on which are off. So, such system is called supervisory control and data acquisition system often called SCADA and so SCADA systems with RTU's gives operators visualization of what is happening a quite far away in unmanned places, they are also MMI, they also have MMI purpose.

Sometimes, you have panel PC's they are special types of PC's with you know touch screens. So, that the operator you know need not type you can just for basically convenience because, an operator has to concentrate on the process and should not be bog down with you know the it should be as easy for him to give commands as possible. So, people use you know devices are touch screen in such environments, so for example, these are, so there could be a variety of you know man machine interface kind of devices, which needs to be interfaced with a PLC starting from operator panels to monitors to PC's to keyboards to printers, so all these it is possible to interface.

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Then, you have programming devices and this is the typical programmer, programmers are of two types, either they could be handheld which you can take to the shop floor and directly program the PLC or they could be table top, where you have and which are of a higher capabilities. And where you actually develop programs offline and may be go on just load it there, because these have very good program development environments also.

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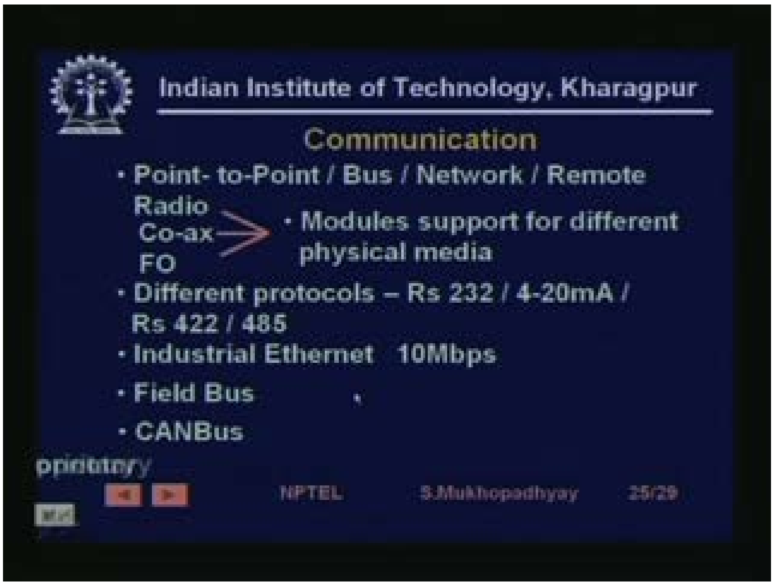

Finally, another very important thing is communication, so there are various types of communications available as we have already told. For example, point to point where you run direct wires from an input or output module to the actual device, they could be bus communication is actually internal to the modules or it could be network communications, where network or remote these we have already explained.

Communication medium can be various for example, it can be radio, it can be co-axial channels, it can be fiber optic cables. So, different physical media may be supported are supported, various protocols are supported for example, RS 232, 4 to 20 milli ampere current loop, RS 422, 485 these are point to point communication protocols. Apart from that there could be network protocols for example, industrial Ethernets are sometimes used where the computational requirements are well known, well understood and you know that due to that is CSM, SED media access protocol you are not going to get performances is not going to degrade.

You have an feel bus that is a new standard for networking in the industrial environment we shall be studying it much more detail. There are other less popular probably I can call them less popular for example, the CAN bus, the CAN bus is more popular in another application environment that is automobiles. Field bus is gaining popularity in the industrial environment and some buses could be you know proprietary for example, Siemens has a bus called Sienec which is a proprietary protocol bus.

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The advantages of distributor network I/O are well understood cost saving on maintaining integrity of high speed signals. Because, digital ((Refer Time: 55:05)) basically they are advantages of digital communication and the advantages of having an intelligent module near the machine. So, you can have good sensor diagnostic false fault can be much more you know monitoring functions can be realize without over loading the CPU. You can do special functions, like start up, so in a sense in such cases the PLC, CPU are really works like a supervisory system and the actual controls is done on the spot, so you have better centralized coordination monitoring.

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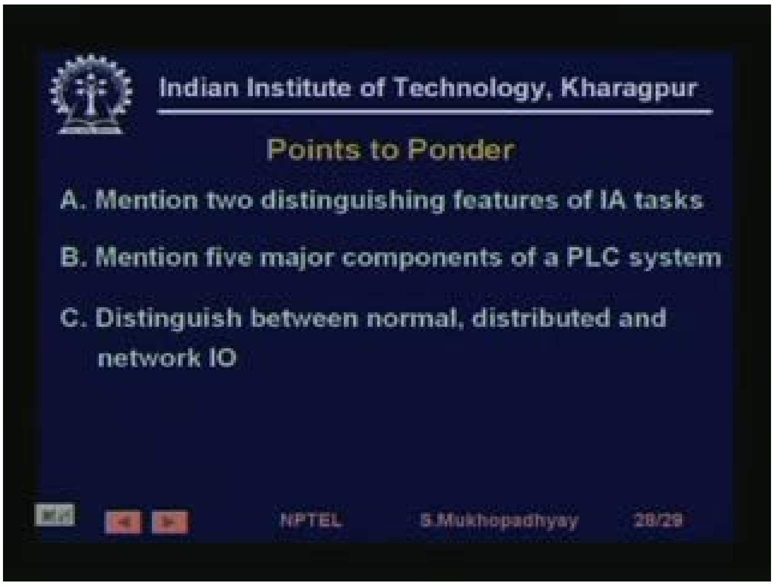

So, we have come to the end of the lecture and so we have I hope you have got fairly a fair idea about what makes a PLC system and as this customary again you have some points to ponders. So, think whether you can mention two distinguishing features of industrial automation task compare to let us say a task in a bank with the which are also computational tasks, which also communicate. Mention five major components of a PLC system, we have mention more than five, so you should be able to mention five and distinguish between normal distributed and network I/O, so here we end today, thank you very much we will meet again.

Industrial Automation and Control

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Lecture - 23

Introduction To CNC Machines

So, welcome to a lesson 23 of the course on industrial automation and control, today we will be talking about CNC machines that is computer numerically controlled machines.

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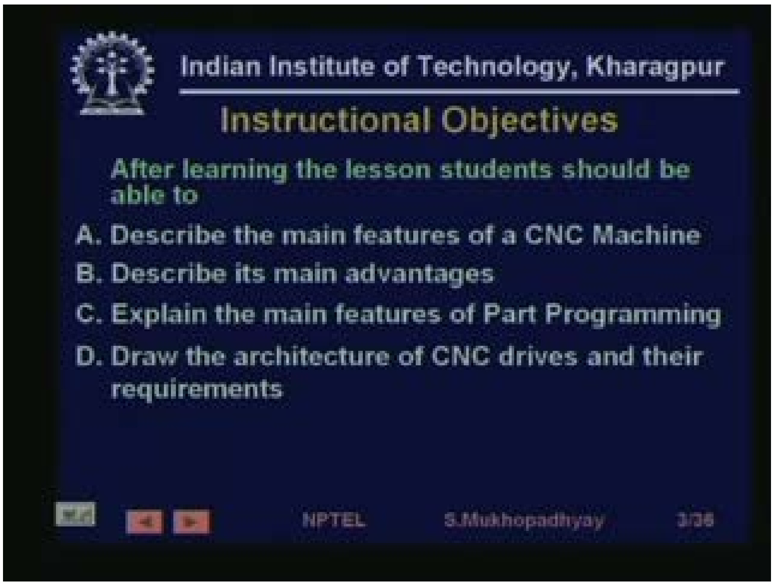

So, as usual let us look at the instructional objectives of this lesson, so after learning the lessons the student should be able to describe the main features of a CNC machine, what makes it. Describe it is main advantages, why we should spend money to buy these machines they are very expensive, explain the main features of part programming, because these machines are automatic they can be programmed. So, the programs are called part programs, so we will see some basic features of part programming.

And finally, the drives the CNC machines create motions all machines create motions, machines especially which used for manufacturing. So, naturally they involved drives, the technology which the generates the power and the control for creating precise motion against heavy loads. So, we will see their these drives and we will see the requirements on the CNC drives, so that later on when we study the drive technology, we can refer to that and we can we will see how these drives are actually realized using electrical machines, power electronics and controls.

On the other hand, the work piece is rotating at generally at very high speed it is, so it is rotating at the same time it can come down to actually drill a hole. So, the work piece in this case is capable of it has high speed rotation and it can also move along one axis, whether the work rather the tool can move along one axis and while rotating and the job can move in have rectilinear motion have motion a two dimensional motion.