INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

On Industrial Automation and Control

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Topic Lecture – 25
Sequence Control. Scan Cycle.
Simple RLL Programs (Contd.)

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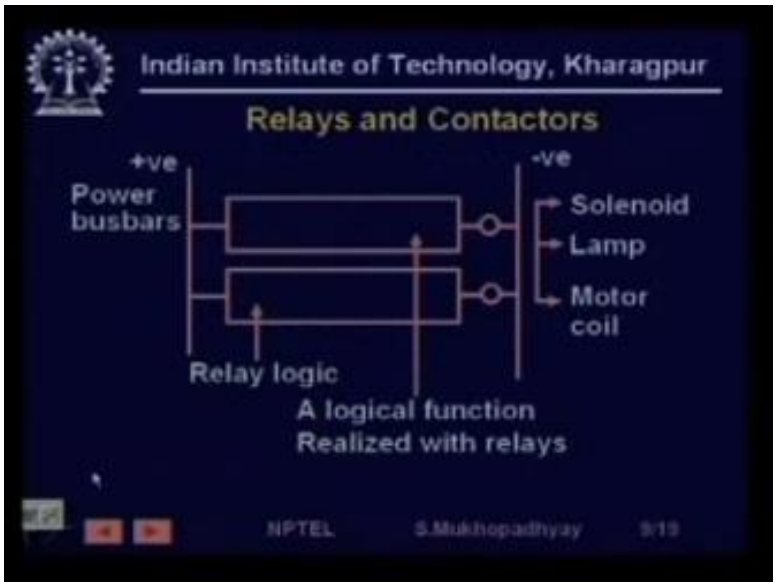

So we go move on and we look at the predecessor of a PLC actually as we have said that PLC is just before the PLCs were invented or made out of micro processors such sequence control problems used to be typically tackled using control panels which typically employed, you know things like relays, contactors various kinds of switches, lamps, various kinds of, you know electromechanical timers and such things.

So they were actually physical devices which were hardwired. So they are typically arranged for, you know ease of maintenance and an installation etc, they were typically arranged modularly.

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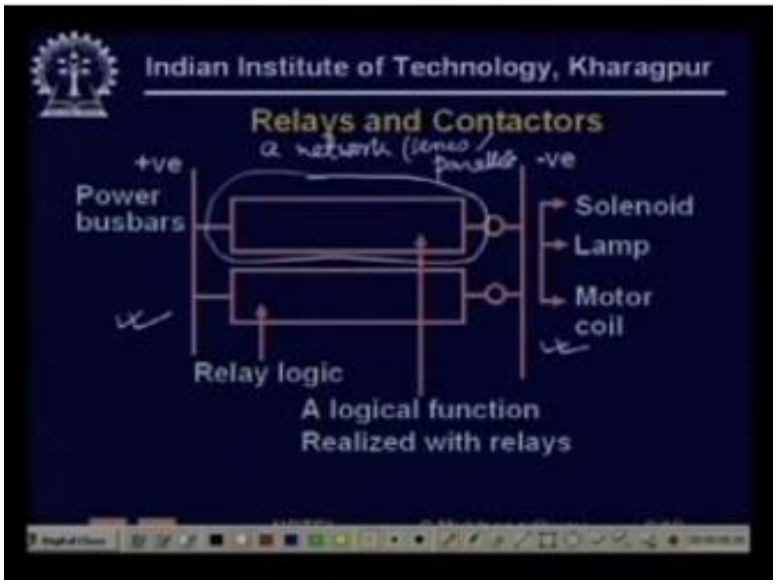

So the typical arrangement would be that there will be a positive voltage bus bar and there will be a negative voltage bus bar and you will implement a particular logic whereas you will implement basically a network which is a series or parallel network series or parallel of various kinds of switches. So and there are only certain specific conditions of these switches this there will be a connection from this point to this point.

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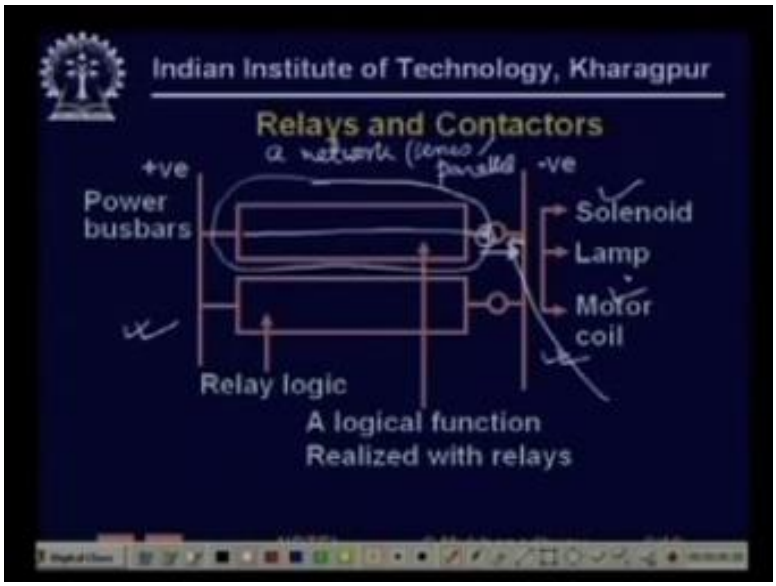

Otherwise under other conditions these two ends will not be connected. So when they are not connected the voltage will not appear here and therefore, current will not flow. And so, whatever this output is this is sometimes used to be called an output coil because they were typically physical devices like solenoids or motor starter coils, so they have a typically coil so they are sometimes called output coils, it is a legacy that they are still sometimes called output coils.

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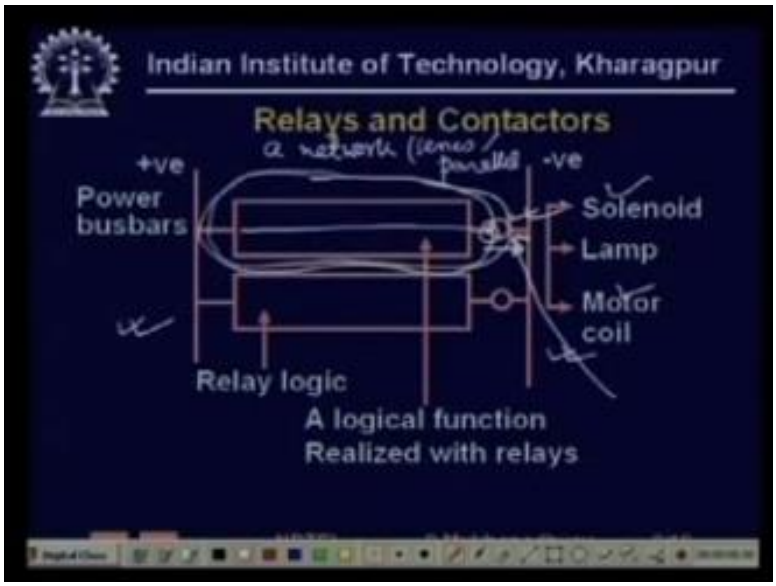

So then the current will actually flow through this, so it is therefore by this switch network you can actually control, you have controlled the situations under which this output is going to be excited. So this is the way things were made and when PLCs were made initially you can always make a new device, but it is relatively more difficult to change the training and the mindset of the people who use them.

So just you know respecting the background of the practicing engineers the PLC programs, the PLCs are nothing but microprocessor based system. So if you see essentially PLC programs are nothing but assembly language programs. However, just so that people can write them and people can interpret them better without making mistakes. So therefore, a graphical kind of programming language was evolved and it was used to, so that the engineers could think in terms of relays and then using some tool such pictures such relay connection pictures could be transformed to an assembly language.

So that is why programmers have to be used to convert such graphical programming language which resemble relay ladder logic, physical relay logic and they actually get kind of, you know

compiled into an assembly language program or a machine language program and they are not on the PLC.

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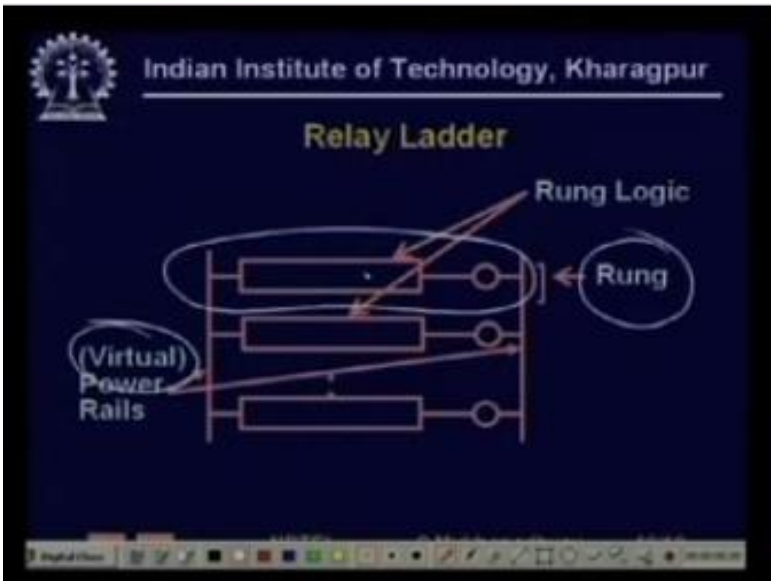

So the kind of PLC programs that will see they are also, they will also be organized like relay ladders while there is no real relay here. So we will draw these power rails which are virtual because this is entirely an abstraction and each one of those, each one of these program statements will be called rung. So there are, so actually these relay ladder logic programs are nothing but a series of rungs having between two rails which are virtual.

So the left part of the rung is a network of the various ladder logic elements like various kinds of contacts, timers etc, and followed by an output coil which shows under what condition that output is going to be excited. So this is the way we are going to draw them. So coming to the so now we have to understand.

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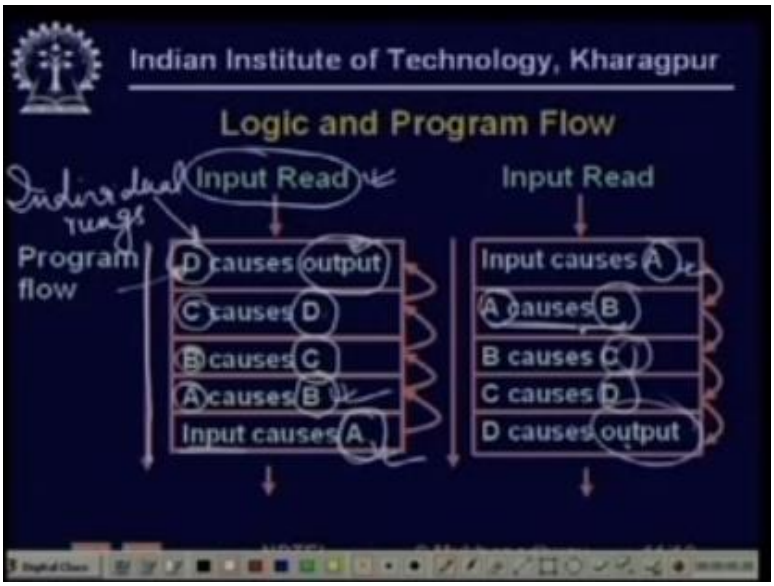

So you see that how the PLC program will be will be executed so one after the other starting from the top after the inputs are read program execution is simply executing the logic of the rungs evaluating the output values from the top one after the other, so typical program flow is from that from the top these are individual rungs individual rungs now you have several logics and they are all executed between one input read and output write output read so it may appear to you that in what order you are going to put these logics one after the other is actually I'm material.

It makes no difference but it does for example imagine that you are you know sometimes what happens is that you if they when there is a very complex logic then you sometimes break up that logic into several parts so what happens is that initially you evaluate one some small part of the logic you compute some value then you use that value and you put it in another expression and then evaluate something else so it may happen that finally we want to compute the final output the final output can be computed based on some intermediate result D which can be computed in terms of some intermediate result C which can be computed in term of B which can be computed in terms of A and finally the input finally A can be computed in terms of the input.

So you have essentially you have broken up the logic into these five different steps now if you write it like this as we have shown then what will happen is that first suppose the input is read which will cause a which is supposed to cause a change in the output now note that these are actually nothing but internal variables this D, C, B, A these four are some just internal variables there they have no there they have just you know memory variables.

So when you will evaluate output you will use the old value of D which was computed using the old input so therefore output will not change in this cycle however similarly C will not change because it is because and B also will not be out will be updated because we are will use the old value of C similarly C will not be updated similarly B will not be updated however A will be updated because now you have got a new value of input in the next cycle this changed value of A will cause a change in B while C and D will still remain C,D and output will still remain unchanged.

So in this way just because we have organized these programs in this fashion we will get a five scan cycle delays between an input read and an output change which is completely unnecessary because if we had organized it in a slightly different way then what would have and suppose we just invert the order then in the first cycle input will change A so a will get change in the first cycle now when we evaluate the second one we contain the new value of A because we are taking it from the memory and the memory has been updated.

So and similarly when B is updated C will be updated when C is updated D will be updated and so in the first cycle itself output is going to be updated. So this is something to remember that the program flow should represent the actual flow of logic that is what causes the other when one is developing real ladder programs, so now we let us let us look at some of the elements which occur in a real ladder program.

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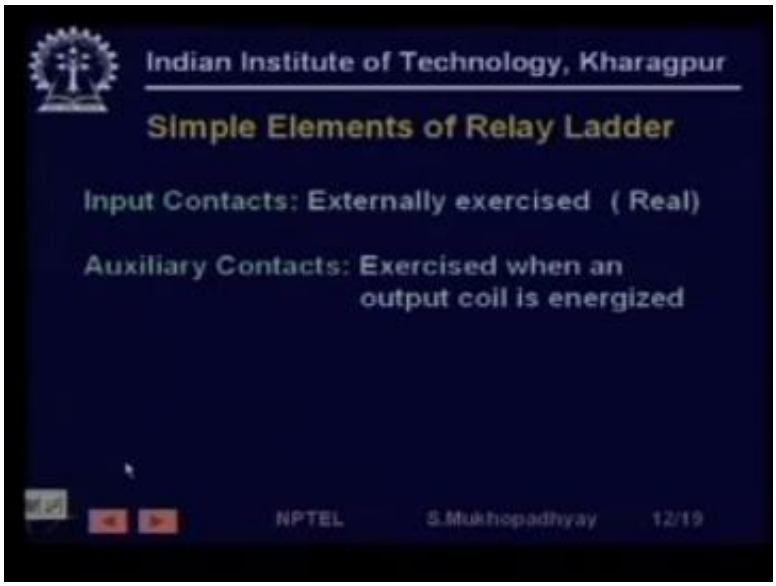

So the simple elements of a relay ladder, today we will look at there are various kinds of elements today we will look at three kinds of elements.

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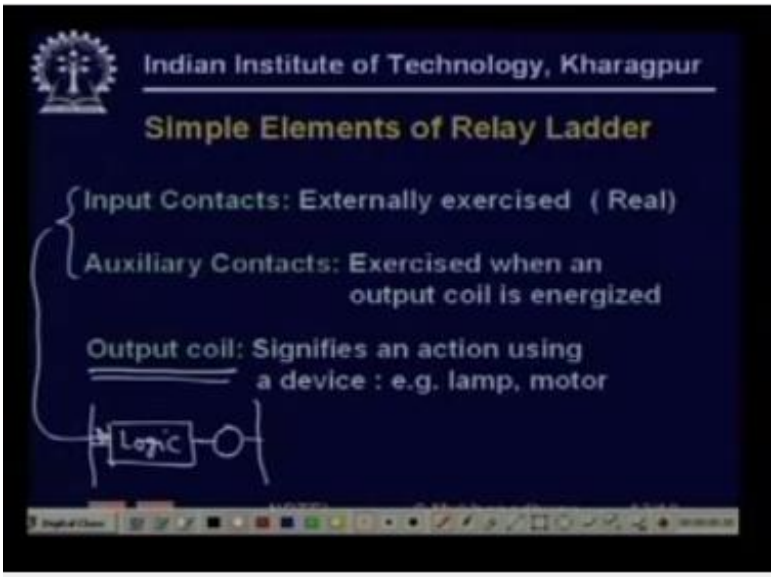

Namely we look at the as you have already seen that there is an the that there is an output coil at the end and we have also seen that it is like two rails then some logic and then finally an output coil, so this is logic. Now today we will study where the logics are just made of some input and output contacts in fact they can be made of many things they can be actually this input and output contacts are you know those who have studied detail electronics.

They are like combinational circuits while we could also put other elements in this within this logic to make this logic a sequential logic using timers and counters and things like that, so that we will see on the in the next lesson today we are going to see circuits which are made simply of various kinds of switches so basically combinational logic.

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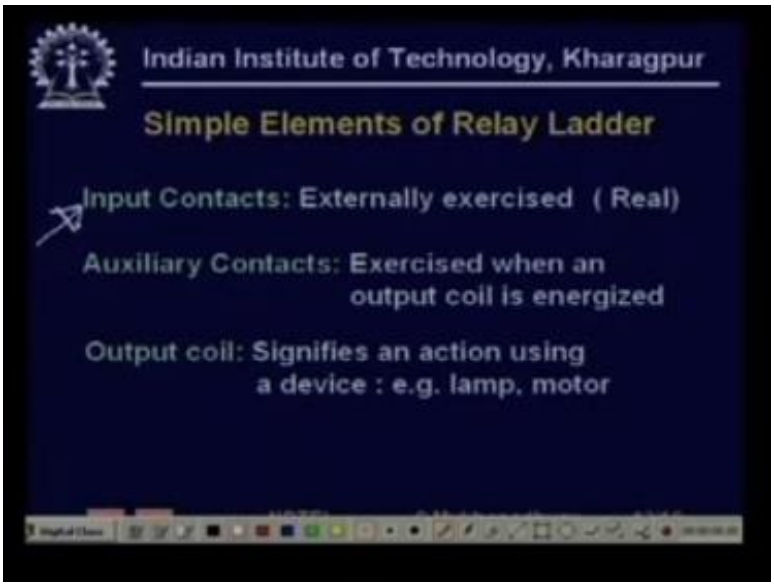

So before we change this we must mention that there are now the switches are of two types, some of them are called input contacts so they are they correspond to these contacts are physical you know they are abstractions of real physical inputs like some photo detector has detected a part so it has changed from 0 it has gone to one, so that one of the so an input contact will correspond to the physical photo detector device.

Similarly there may be a limit switch or there may be a pressure switch so these are all there may be a push button which the user pushes physically the maybe the operator Pushes, so such contacts will be called input contact.

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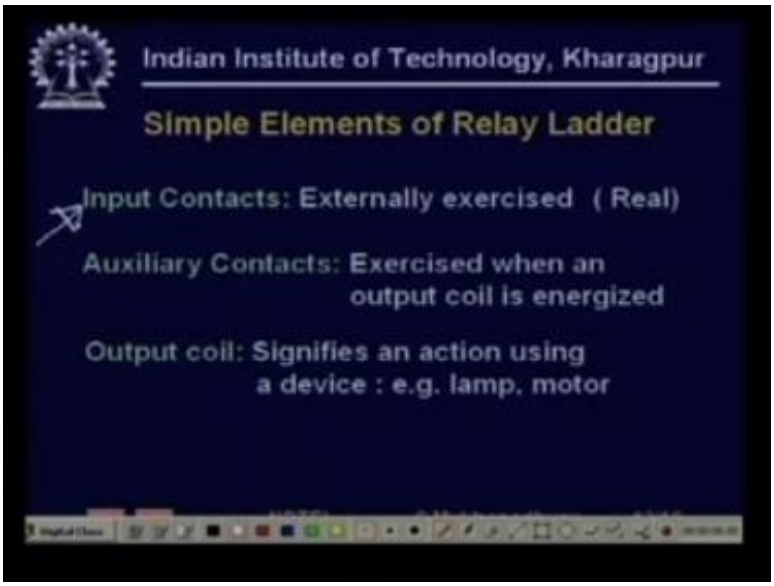

Which are externally exercised by the machine that means external to the PLC and which are real that is there are corresponding to these contacts there are real physical devices.

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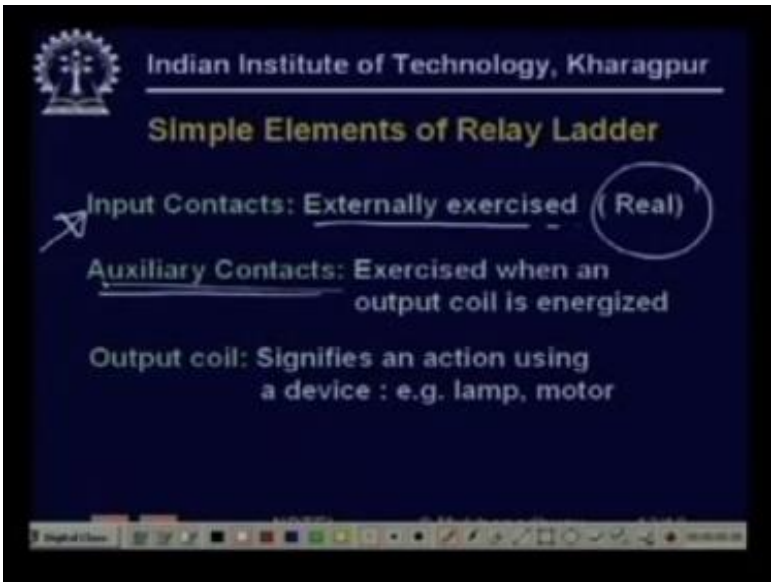

On the other hand sometimes we will use some memory variables as contact for example as we have said that we can have we can use some value of the output coil suppose they the output coil value of the i^{th} we may use in the J^{th} run so how are we going to use that so we so this to use the value corresponding to the to an output coil we will create an create a contact such contacts are called auxiliary contacts.

So they are they have no physical they have they have no physical existence they are simply just memories, okay. And they are used actually for logic evaluation and they are exercised.

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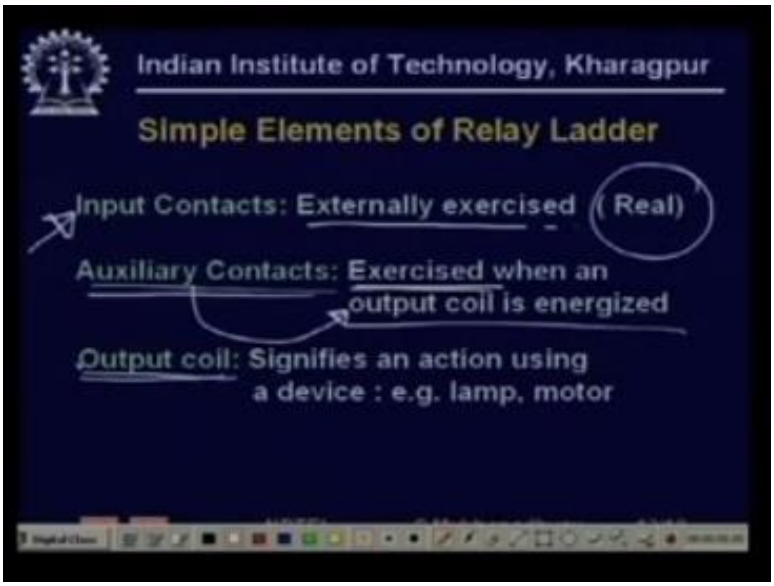

When an output coil is energized so these auxiliary contacts correspond to output coils and finally an output coil is that is also a corresponds to a physical output in the real external world. So now so these are the three elements with which we first will control construct our simplest PLC programs there are we will use two types of contacts.

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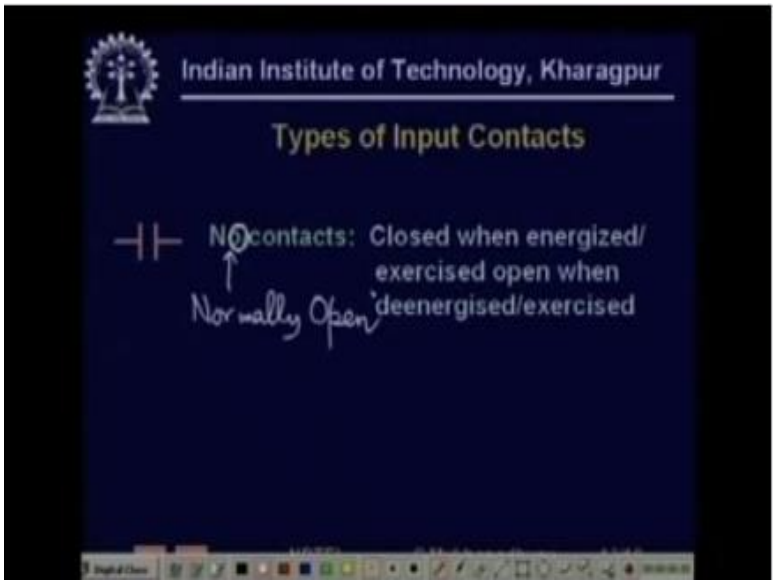

The first kinds of contacts are called not no contacts they are NO contacts NO means normally open similarly so this means that when the these contacts are not energized or they are in the you know they are unexcited or de-energized States then this contacts should be as should be assumed to be open because we always interpret PLC logic as if some switch is going to open so we work we are always looking for closed paths on the RLL programs so when the when that contact will for example.

Whenever a push button is not pressed if it is represented by an a NO contact then when it is not pressed that that contact in the RLL ladder logic is going to remain open so we must interpret it that way similarly we might have.

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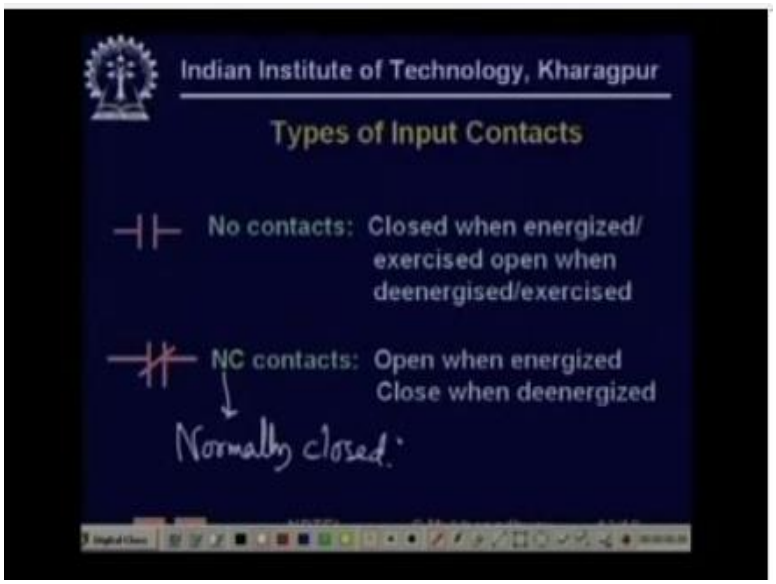

And what is known as NC contact where NC stands for normally closed so the same push button if were present it by an NC contact then if the push button is not pressed that is when it is not excited that contact will remain closed so we must interpret it that way in the PLC logic when we try to see whether there is a continuous path from the from the positive rail to the output coil positive end so it is open when energized and it is closed when de-energized.

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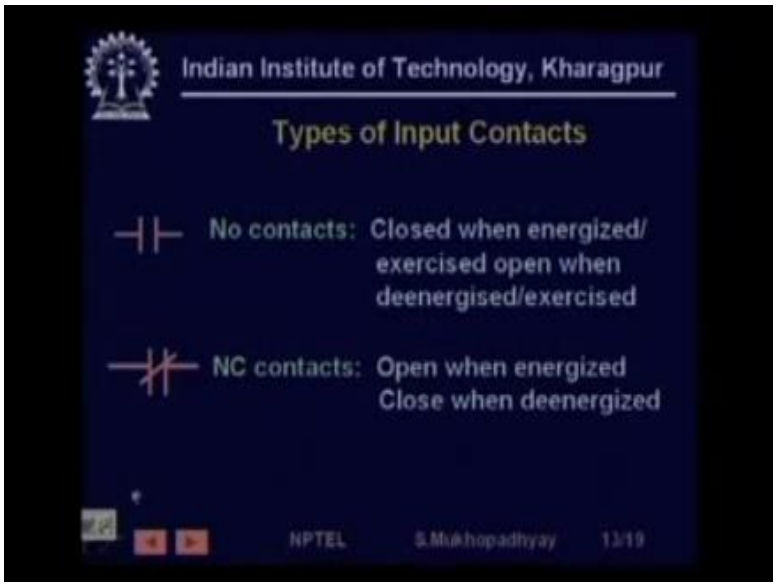

Now.

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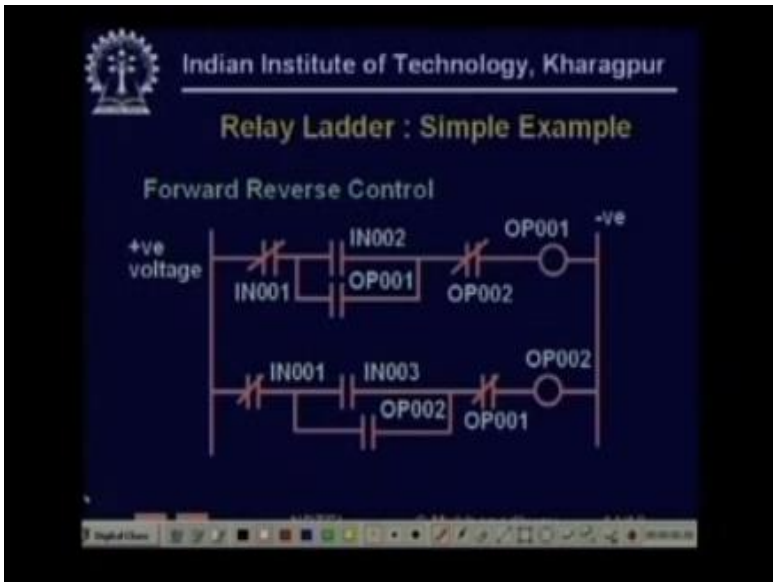

We will look at a very simple example this is an example which is it is a simple version of an example which is used typically for let us say motor control so you in that we have a motor and we want to there are there are two push buttons one says go forward so the motor will rotate in one way it could be a movement of a motor it could be a move movement of a plunger in the forward direction similarly there is another push button which says go in the reverse direction so how is this achieved this typically achieved by if current flows in so maybe there is some solid somewhere.

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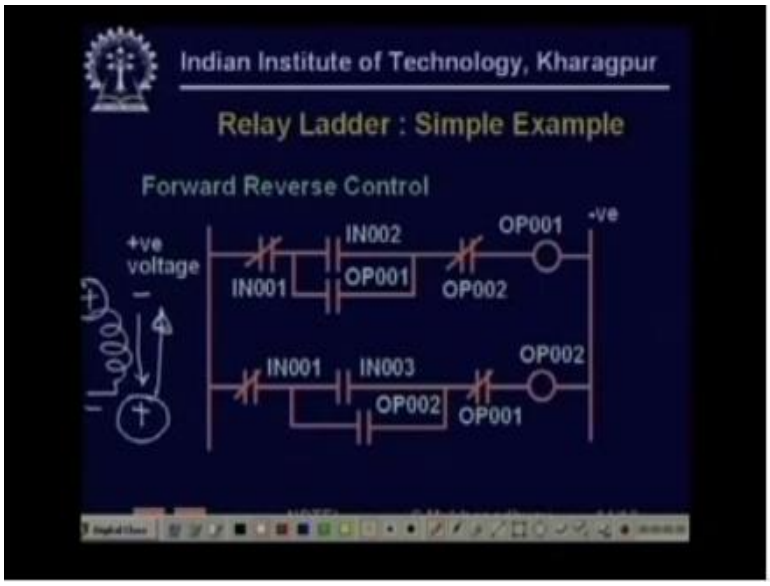

So if this is positive this made positive this negative current will flow in this way and then the motion will take place in one direction on the other hand if this is made positive and this is negative then current will flow in this way and then probably the motion will take in the other direction this is the way it is done so there for some time you have to connect the positive terminal to this point and sometimes you have to connect the positive terminal to this point now potentially hazardous situation exists.

That is if by chance there are two different switches if they are pressed together then what is going to happen is that the positive terminal and the negative terminal will get shorted this may cause an accident so we want to have a logic we do not feed the push buttons directly rather than we take it through a PLC so that we ensure that even if they are pressed together no such problem will occur so now we see what is going to happen.

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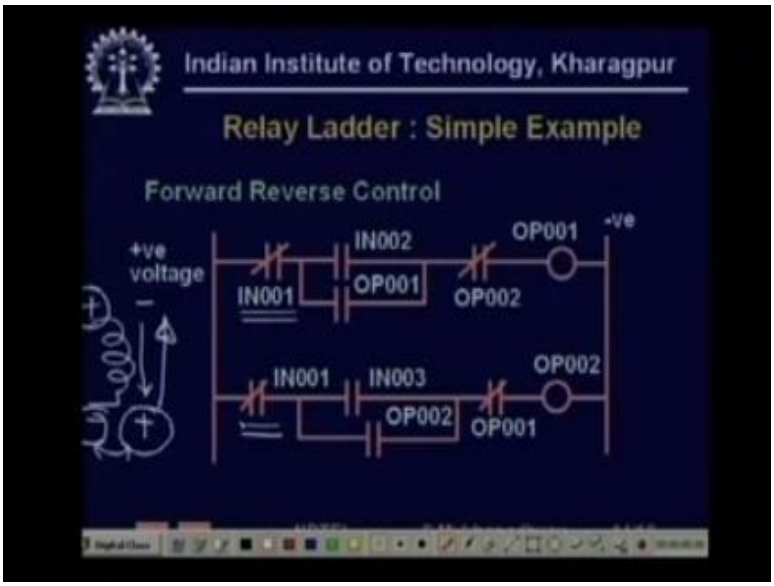

So you see that these two push buttons corresponding to each push button we have two contacts so corresponding to the first push button which we called In001 we have two corresponding to I n001 yeah okay now easy sorry this I n001 is actually a master control switch so nothing will happen the CC the motor will not wrote either this way or that way if unless this switch is.

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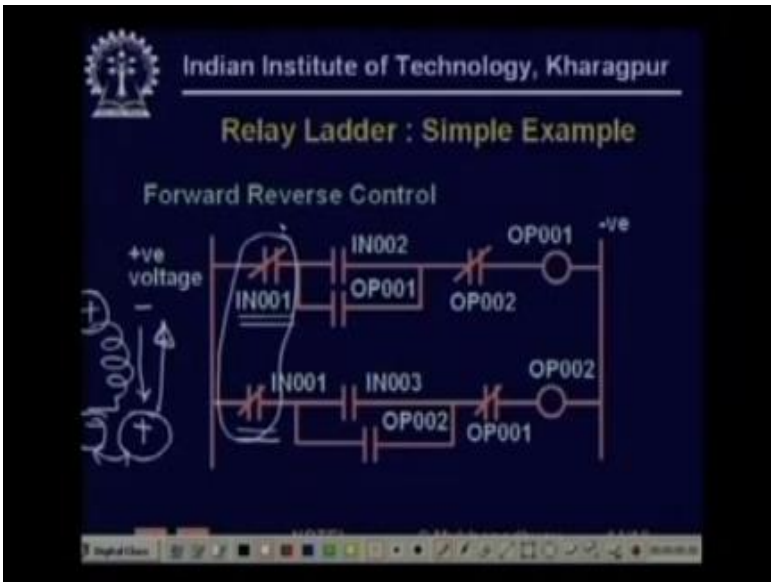

If this switch is pressed so this is like and this like an emergency stop you know this model has three modes so it has a mode move forward it has a mode move reverse and it has a mode stop so if this is actually a stop switch.

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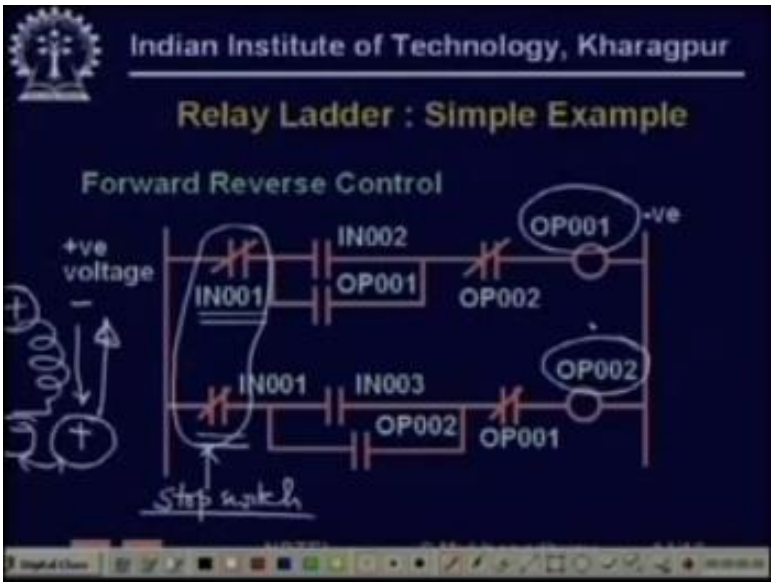

So you see that and these are the two output coils which you can say symbolizes the arrangement of switching the power supply to either the positive and the negative, so when this goes becomes one when OP001 becomes 1 then the motor gets supply in one way and when OP002 becomes 1 the motor gets supply in the other way and when both are 0 it does not get any supply so it is standing. So we see first thing we see that these are normally closed switches.

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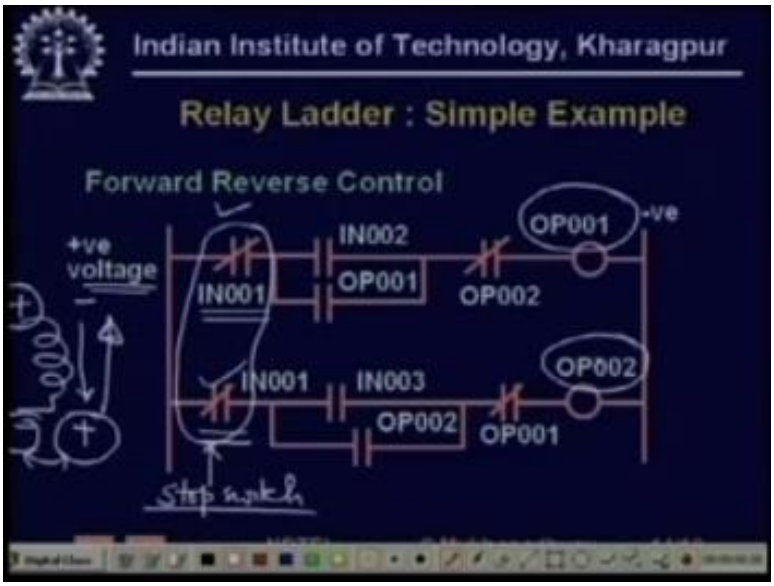

And when IN001 is excited or the stop switch is pressed then this will become open, because they are normally closed. So therefore, obviously there is no question of this positive rail they are getting a continuous path to the contour output coil so both will be off fine, so we have satisfied that condition that is the stop switch is pressed it is going to be 1. Next suppose the stop switch is not placed so it is off.

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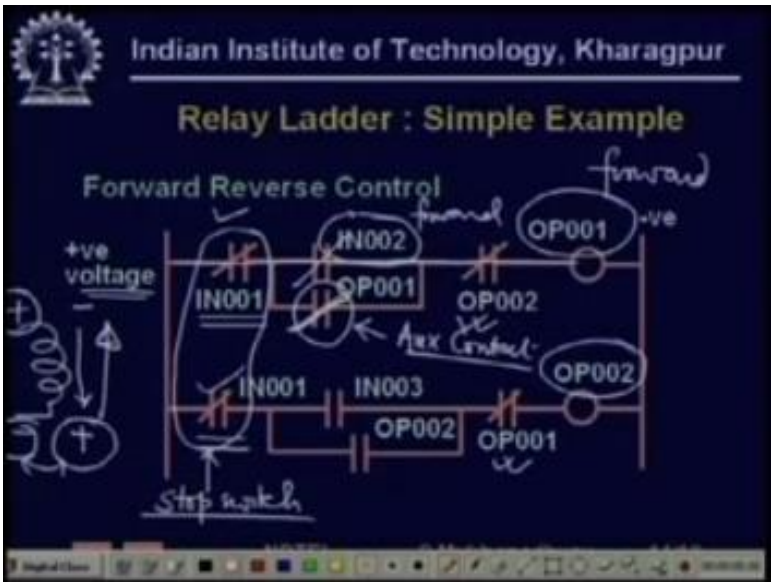

Now if we pressed suppose this is the push button this is let us say forward, so if this is pressed now you see initially both are off so therefore this is also on and this is also on, so when this is pressed this will become on, and there will be a continuous path to the output coil. So this is the forward coil and the motor will start moving forward. Now note that this is an auxiliary contact, so the moment this gets supply or becomes 1 this is going to be excited so this will be closed.

Now even if you remove this switch it is a push button so you have to you have to press it and then you can release it you cannot keep holding it, so you press it once and immediately even if you leave it the motor will keep running that is the arrangement that we have to make, so that is made by this parallel path.

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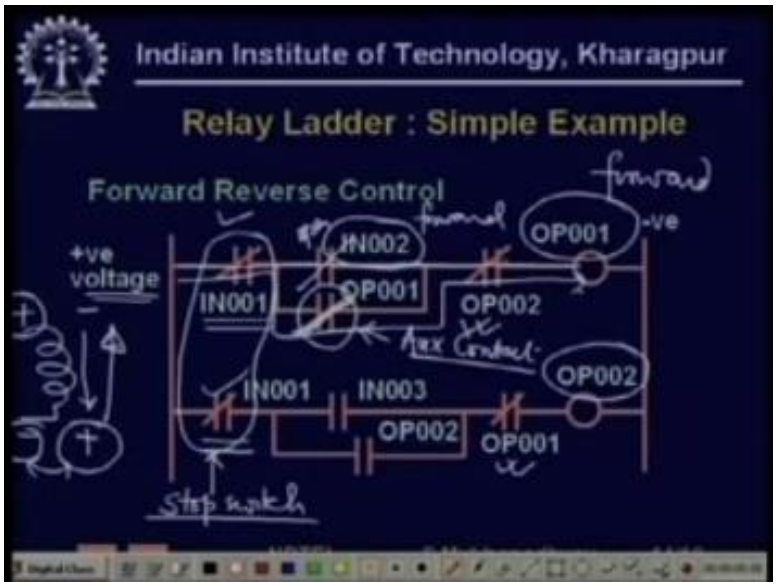

So after this has become on even if this becomes, again this becomes open there is still a parallel path and that parallel path is this one. So this forward coil continues to get supply and the motor continues to rotate. Now in this position where while the forward coil is on suppose somebody presses the backward coil or the reverse coil what is going to happen.

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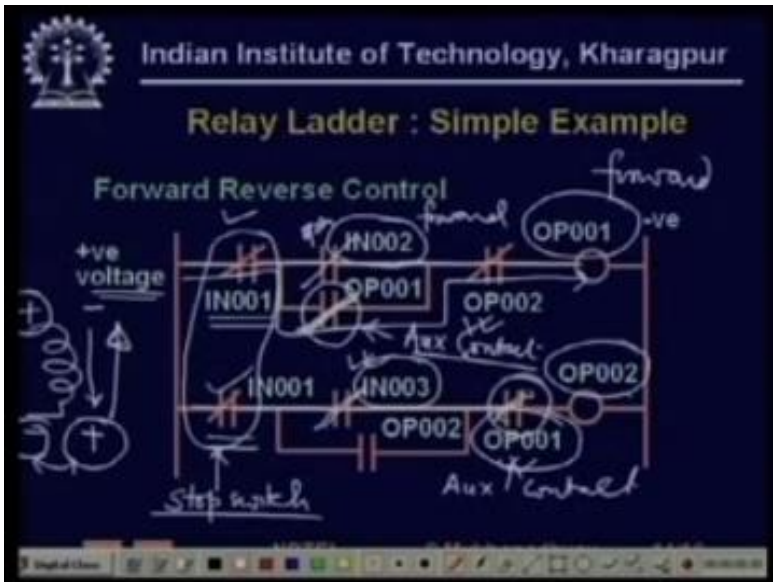

So that this will become on but interestingly nothing will happen that this coil will actually not get supply because of this one which is another auxiliary contact. So whenever this is on this becomes excited and this becomes open so this will be open which means that even if this is already open because this is off, so even if this is becomes on there is no the continuous path stops here because this is open.

So therefore this cannot be excited while this is on if you have to excite it you have to first press the stop switch by which both will become off this time you can press this one then this will become on and similarly when this is on you cannot press you cannot make this one exciting, so this is a standard forward reverse interlock which ensures that simultaneously you cannot command the motor to move both ways. Before we end let us let us look at another example.

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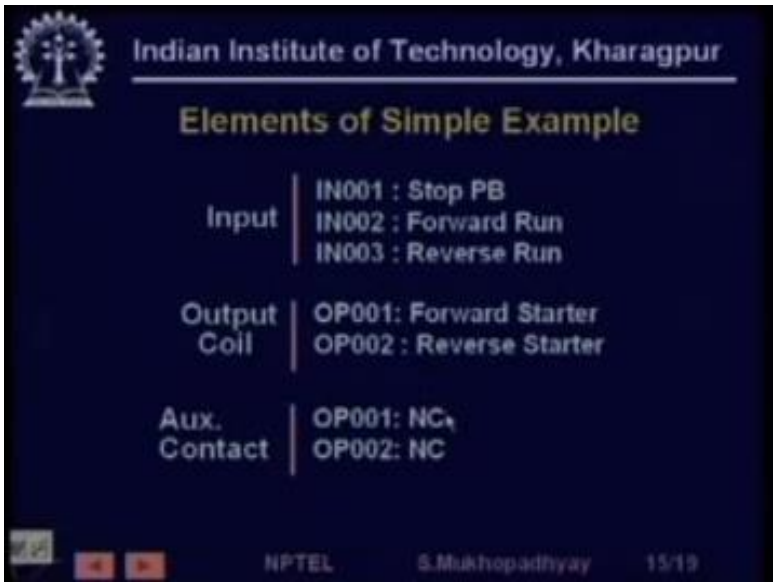

So what are the elements, so the elements of the example are the IN001 which is the stop push button IN002 which is a forward run push button IN003 which is the reverse and push button and the output coils are forward starter and reverse starter and the auxiliary contact NC and NO also corresponding to the piece, so there were NC there is one NC and there is one NO.

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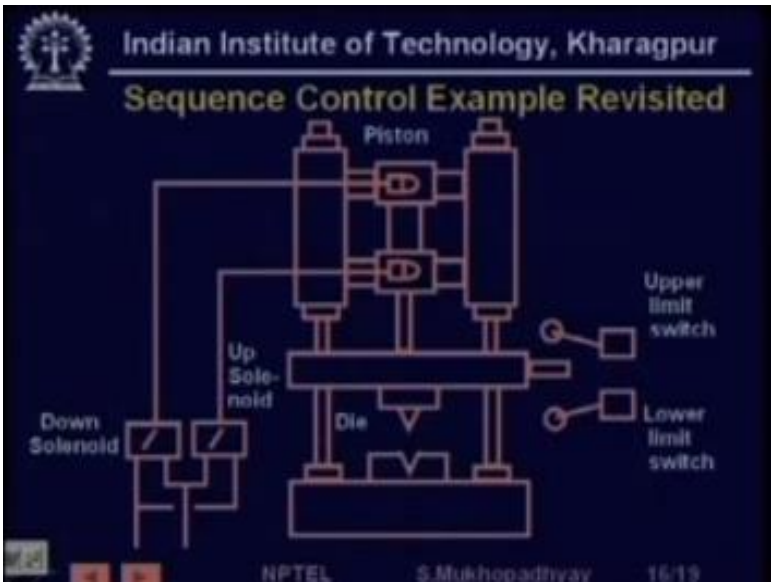

I am sorry, anyway that we have studied, so now let us look at the second example, this is our old you know dye press and we know its behavior we have seen it in the in the earlier lesson. So now we have to design a controller for it a control logic for it such that whenever dye is that is whenever some switches master control switch is pressed it keeps on going to a cycle, okay. So we will see its simplest version.

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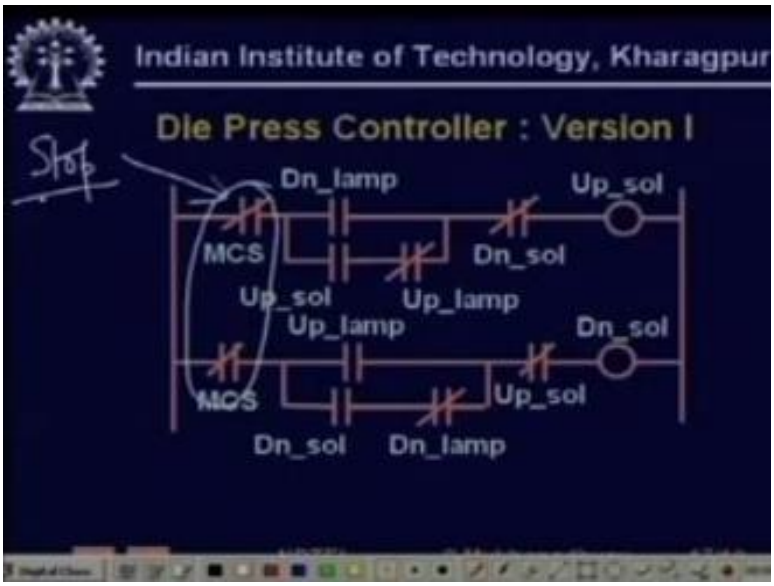

So you know it is very similar to the forward reverse control because here also there is a forward reverse motion only thing is that so you have a master control switch again so if the master control switch is if it is master control stop it is kind of emergency switch so if it is flicked then this machine does not work so neither up solenoid not down solenoid will get supply that is fine, now initially suppose the press is in the is in the bottom position.

So the down lamp that may be that may be the parking position or the shutdown configuration we are not discussing how it will come to the shutdown configuration we are just saying that from the shutdown configuration if it starts I mean how does it start.

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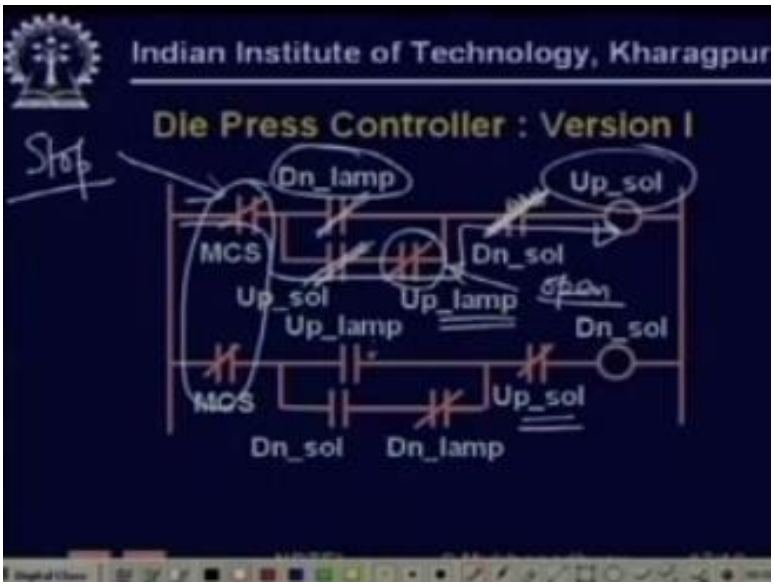

So because the down lamp will be made so this will become on the moment and so initially now initially yeah down lamp is the so what will happen so it is down and because the down solenoid is off so therefore this actually is we should have this as an N 0 contact so then this will become on it will become now it will become no your right so I correct it is an NC contact this is this down solenoid is off.

So therefore it is closed so when the down lamp is closed immediately the up solenoid will get immediate in the up solenoid will get supply so when the up solenoid gets supply again this will because this an auxiliary contact so it becomes on, now there is a path through this way note that as it moves so immediately when the up solenoid is on the press will start going up and when it goes up the down limit switch and the down lamp will glow will open.

So even if it this opens but the up solenoid will be on and keep going up now the point is that it must stop somewhere so when it will reach the uppermost position at that time the up lamp will glow when this will be growing this will become open so then the up solenoid will become zero so now the up solenoid becomes zero so therefore this is closed and the up lamp has grown has

grown so this is now closed so immediately the down solenoid will now get supply. And when the down solenoid gets supply this is closed.

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And the down lamp is anyway not excited so therefore it will start coming down and then they are then the up lamp will open but still there is a path in this way and the down solenoid will keep getting supply and so the press will keep coming down under hydraulic pressure so you see that using another contact.

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We have we are just ensures that there is that there is alternating motion.

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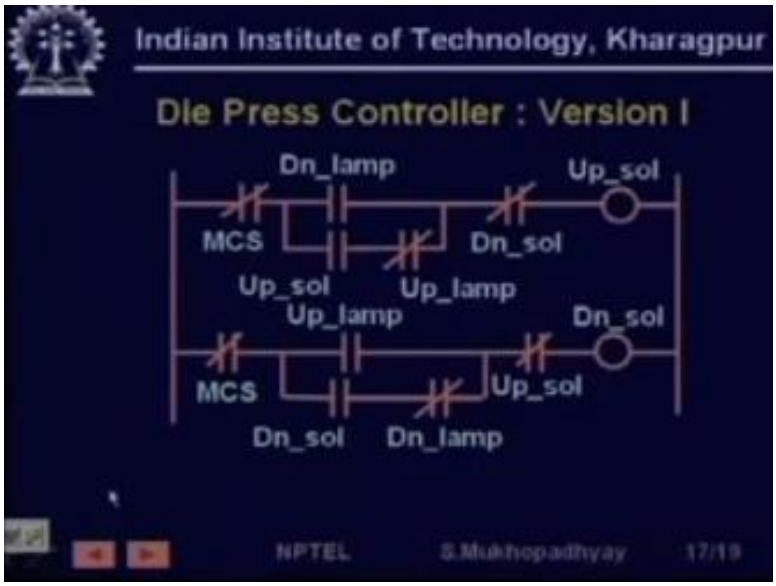

So these are the two examples of RLL that can be constructed with simple contacts to review the lesson we have scan.

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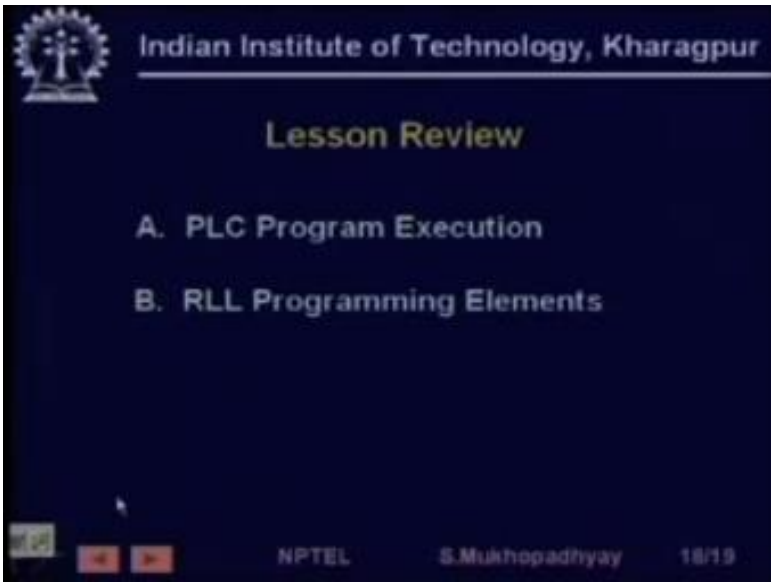

We have seen three major topics one is the one is the PLC program execution the second is we have seen the simple RLL programming elements of NC and NO contacts and input and auxiliary contacts as well as output coils and finally we have seen two simple RLL programs which have shown that how to create interlocks and how to create alternating motion.

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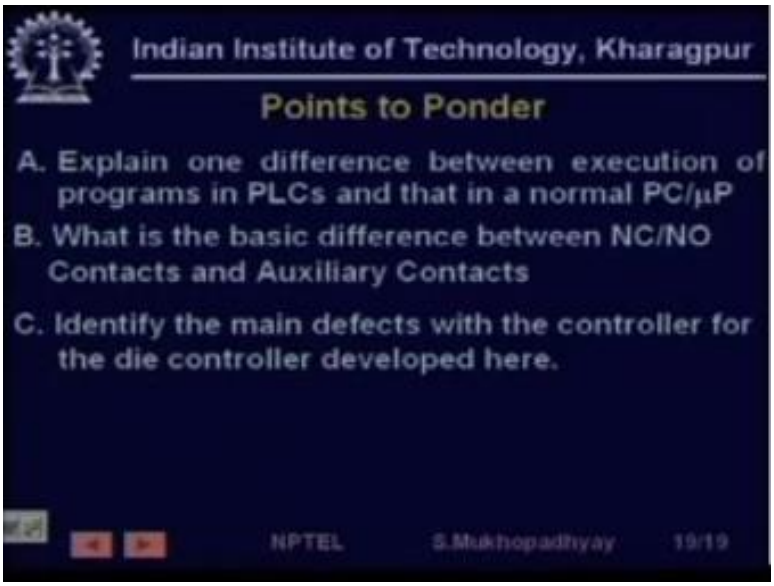

There are some points which you could test questions or points to ponder for example what is the difference between the execution of programs in PLCs and that you could write in a normal PC or a microprocessor as we have seen that the differences in the way input output is done what is the basic difference between normally closed and normally open contacts and input and auxiliary contacts and you could it will be interesting to see that what could be possible defects.

We have the die press controller that we have given is a very simple controller what could be possible defects with it.

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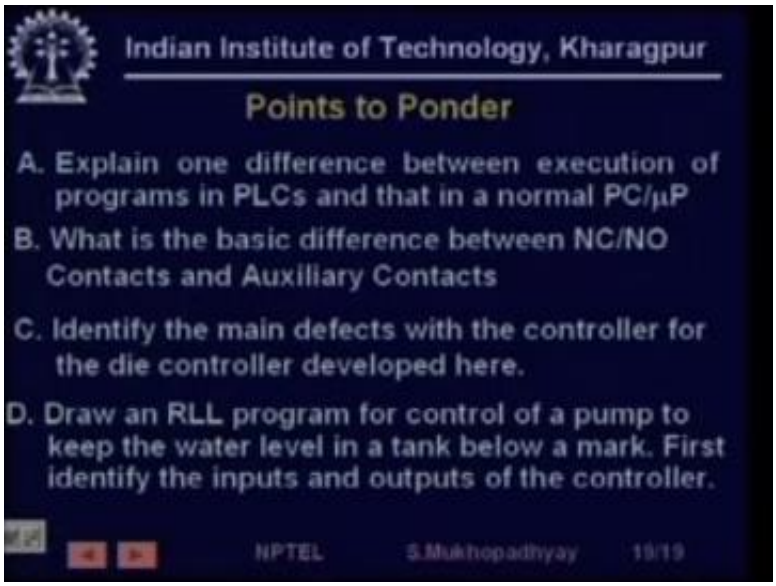

And finally it will be good if you can try and try to draw your own RLL program for the control of a pump to keep the water level in a tank below a mark so imagine that your house in the house you have put some PLC control such that you never run out of water and it will sense the water level so a very important part of but before designing the RL is to identify the inputs and the outputs of the controller.

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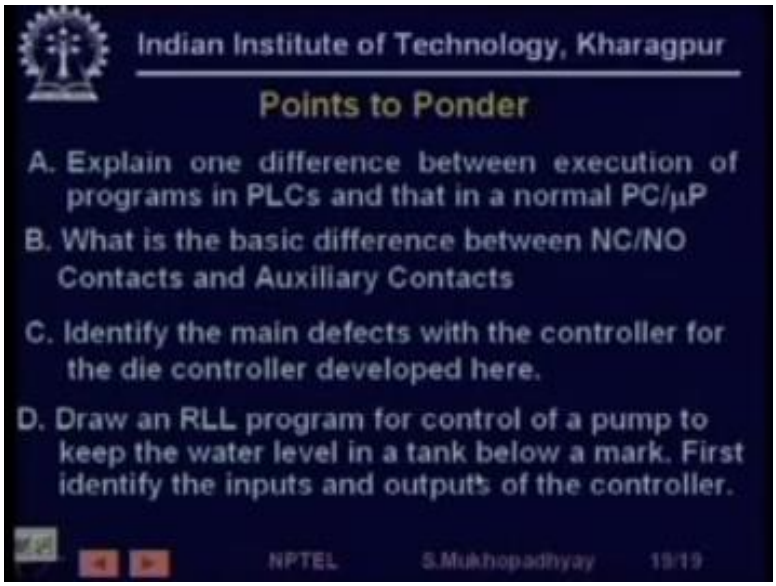

What sensor you are going to use what are going to be the outputs of your PLC etcetera then try to write the RLL program. So that is all for today, thank you very much.

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We see for see the next lesson in the next class, thank you very much.