Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Digital Switching

Lecture – 22

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So in this video we are going to now look at white sense non blocking switch I will give you an example and of course will formally prove this time by using a state diagram basically we will take the switches states and then this tone how the transition happens from one state to another you will be actually figuring out and algorithm by which a switch will never enter in a blocking state okay so important thing to know is that.

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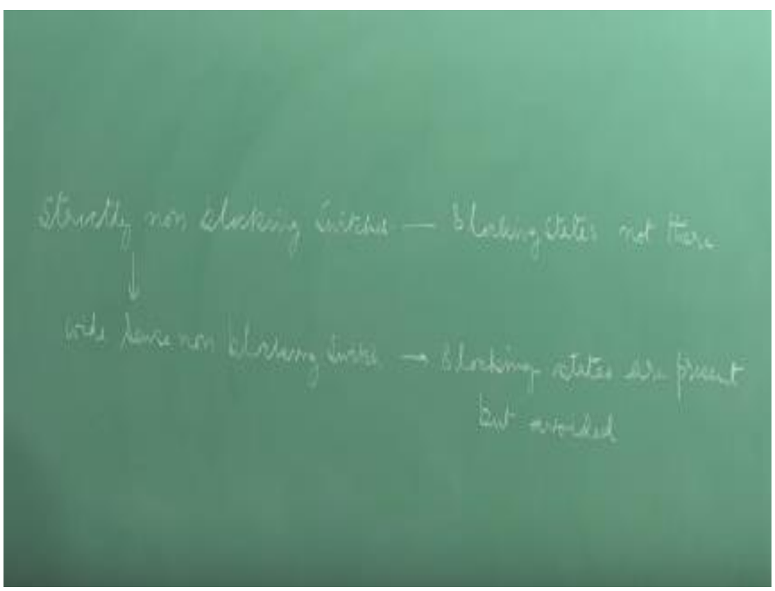

If it is a strictly non blocking switch we have done this switch actually does not have a blocking as state you take any configuration any input output connection map any possible way the roots have been setup switches always in non blocking a state so given in free input and free output port you can always setup a connection but they are scenarios where it is possible that you have a switch design where there are blocking a states but you can actually implement you can operate the switch in such a fashion switch will never enter into the blocking state so wherever whatever we those.

Non blocked state when a new connection comes in you try to setup connection such a fashion such that you will never enter into a blocking a state so therefore a switch technically operates in a non blocking fashion all the time just by using a suitable procedure and this kind of switches are white sense non blocking switches okay so important thing now the method which I will be using so we are now moving from here to white sense non blocking here blocking a states are not there here blocking states are.

Present but they are avoided but they are avoided actually okay now when I talk about this and I say I am going to proof it using a state diagram now one of the problems with the states is if for example you take a simple 2/2 Ben's network.

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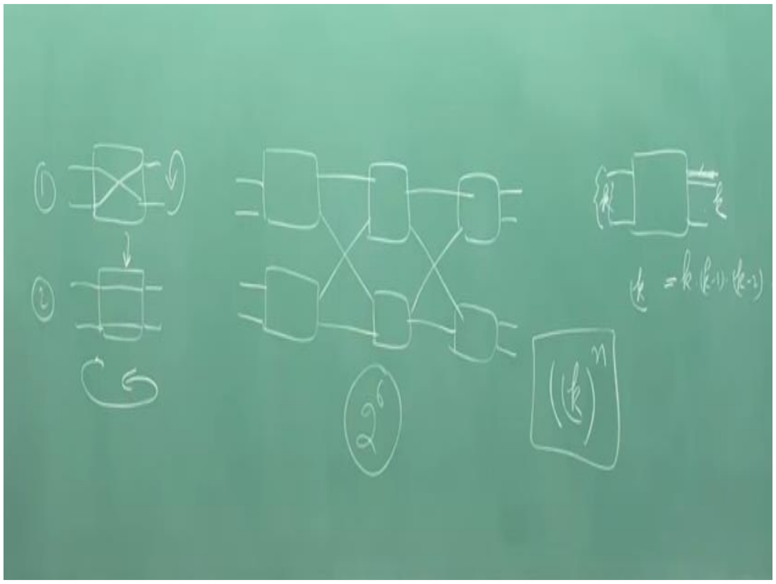

So how many possible states of switch can be in actually so if you take a simple 2/2 cross bar so what are the possible states of possible states are switch can be either in this configuration or in this configuration okay there only two possible configurations of a binary switch is a binary switch okay so if I create a switch like this now can you guess how many possible states the switch can be in this is the Ben's network of a 4/4 these are 2/2 they are two possible states one and two how many possible states are they are in this case.

Okay so each one of these 2/2 can be either in cross or in bar and their total how many switches 1 2 3 4 5 6 so their total 26 possible configurations okay which implies 64 possible combinations which actually can exist in this case there only two combinations which can exist so if you have any switch and of course if you this is not a 2/2 if it is k/k so total number of possible combinations with which connections can be mapped if it is a strictly non blocking cross bar it will be K factorial.

So the first output can be connected from the k inputs were this has been busy there only k – 1 free so next one can be done with k – 1 and so on it will be k, k x k – 1 x k – 2 into 1 and so on so this will be k x k – 1 x k – 2 and so on till one so which is nothing but equal to k factorial and if they are actually using such of them say some number per stage you can actually estimate some switches total number of a stages so you will end up in k factorial raise power total number of switching elements and which are use these many number of possible configuration states are there.

Okay even this actually has got 64 so how we will do the analysis there is such a large number of a states so views of concept called equivalent states now if you carefully look this one and two possible configurations they both are and technically same they are not different so there is only one state actually so I can just simply twist input this one so I can twist here and this will end up in this particular thing I can twist the whole switch is still remains the same I can twist this way does not I am not looking at specific pattern.

I am looking into the geometrical pattern which by translation or by moving the switches around oh by rotating them can be converted from one form to another they are all equivalent configurations so let me take an example of 4/4 but two stay switch and try to give an example of the equivalence actually happens what do you I mean by rotation translation or symmetrical transitions in that in the switch is still remains in the same states which I am actually not all changing any corrections okay but still all of these states which will be coming will be all equivalent so let us take a 2/2 because once we know this particular motion of equivalence I can use it to build up the non equivalent states with one connection and so on of course I have assume that there is no connection so for a 2/2 let us start with this and then.

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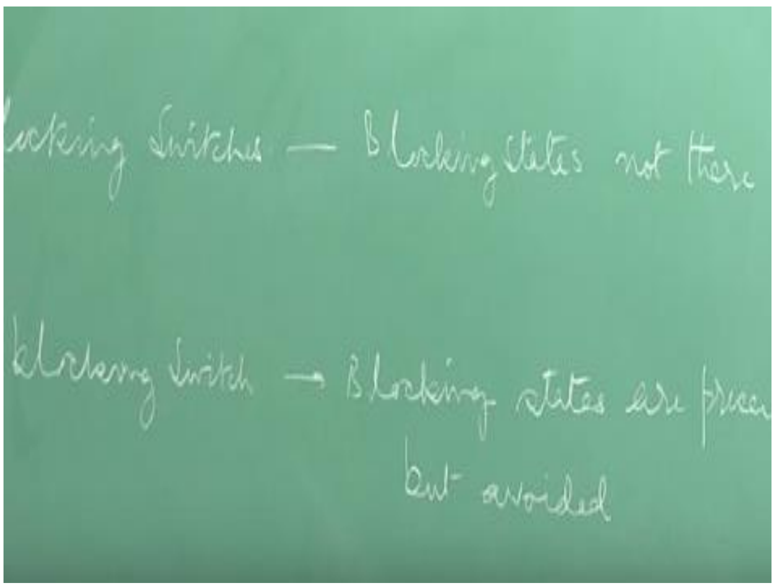

And then I will move to 4/4 by two stage their two inputs two outputs this is only state when no connection has been made second possibly state can be when I make only one connection okay now in the connection can now be made in this fashion also, but if I twist it around I will get this same thing back so these two are equivalent states actually okay where I make two connections, I can make the connections.

In this fashion or I can make connections in this fashion these two are also the equivalent states I have to just twist it around and I will get this so there only three states 1 2 and 3 in this case okay I am actually assuming here I am also looking at if the connections are not been made that is also one of the possibility, so I am also counting this okays so total three states non equivalent states in this case which are present when I actually gave you an example of the 2^6 I have not considered the states.

When the connection are not been made okay so we will also look into that now let us do for 4 two stages 4/4 system build using 2/2 cross bar and see how we can actually transform from one state to another state and both are equivalent, what they could actually means.

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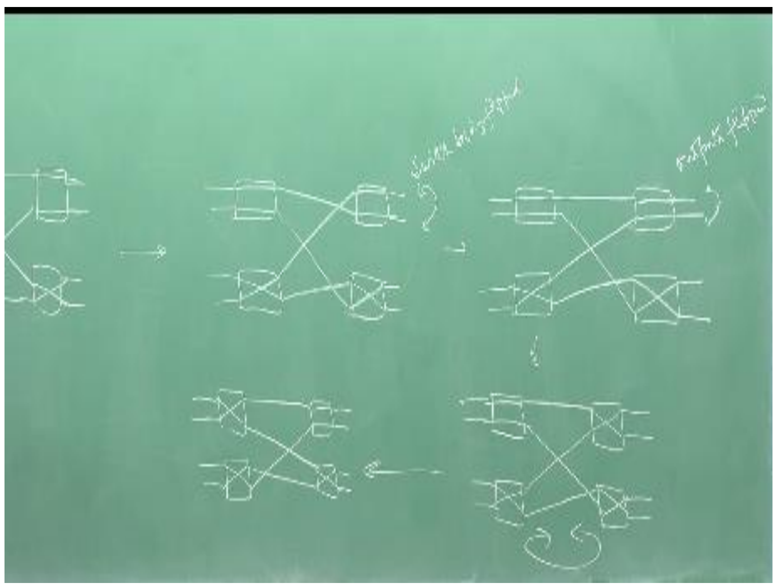

So in this example I have taken remember this is the blocking system this not strictly a non blocking only 2/2 this element this cross bar is a strictly non blocking element but this whole switch per says a blocking system, so a connection for example you want you can set up the connections so I am setting all four of them and trying to figure out the what do you mean by equivalence.

So I have set up a connection in this fashion, so this is the connections the way it has been made, so this one state, now I can do the many things in this case I can now swap between these two I can take this particular 2/2 square switch and move it here and this one I can move down these two are remaining there I am not changing any connection path, all wiring is maintained is it is switch 2^0 will be equivalent.

If you do this so this switch had moved up these two has been kept as it is. So you can actually clearly see I have just simply moved it up so these two wiring remains the same so this one has to be brought to the bottom, so this one will connect here and this one will connect up and down so this is these two are equivalent but what I have done is this transition this one possibility, second possibility is.

I can do the flipping of the outputs so I have technically twisted the switch so once I do that what I will get is, this so since I have twisted this one the output part, okay let us actually flip the whole twist the whole switch so inputs and output both are flipped so this will now get connected to the bottom this where earlier connected to the top and whatever was at the bottom one will come here.

These inputs also will get changed actually, okay. So I will end up in getting this and this and of course this is going as it is, these two are also equivalent I can simply twist the outputs also that is possible and keep the input as it intact, so if I do it here so this is the switch being flipped outputs being flipped so you will end up in getting a switch of remember all these states are equivalent all these are going to be equivalent.

I can turn it around I can turn it in this fashion, then also it will be equivalent so I can do it this way so I can just turn it around and then these two are also equivalent so that is what the equivalent states actually means, so we will use this in our proof to formally reduce the number of possible states which can exist in the system, so let us move on to the example, this example actually has been taken from a paper which was published a electronics later.

So you can search there actually and get this paper, so on my notes which are available on the Brihaspati the reference actually has been given for this particular and this is the one page paper actually, so the switch which is white sense on blocking is this configuration.

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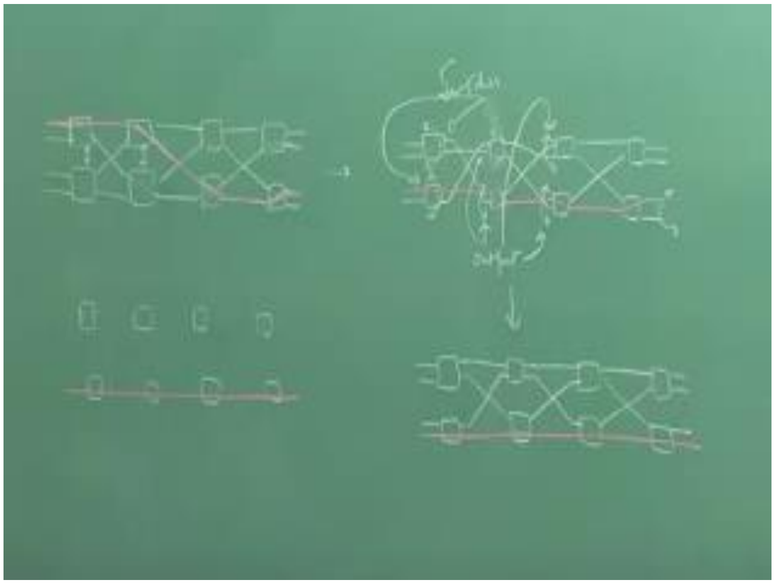

And this is not a three stage system this is a two this is a four stage network, so remember we had done Clos network where there were three stages so herby just adding one more stage and able to build up a white sense non blocking switch, okay. Actually it is a blocking switch but blocking state is there but we will avoid the blocking state I hope you can actually see it and where the blocking is happening.

Now each one of these elements boxes is a 2/2 cross bar, okay. So when there is no connection this is how it looks like the way I will represent it when there is no connection I will just simply draw the boxes there is no lines so need not show it but topology actually is this, okay. So when the first connection is made from any input to any output you can make the connection you can make the connection this way.

Or if you want you can actually make the connection the other way around with any other possibility you can make the connection, in this fashion now is this one connection thing equivalent and that is the question, so I think I can transform any possibility any 1 to 1 connection to only one single state, so let us actually see if it happens, so if I am going to make a connection like this.

To which state I should be able to transform it to, so may be what I can do is, I can do the swapping between these notes and let us see what happens, if I do this I will get so this actually has been swept down this has been pushed down these remains intact so these wherein will remain okay. So let me not actually put these links okay fine I think I should keep the links and use a different color for the one with connection which has been made so that you can trace it this is the connection which I am talking about so I will actually draw the same diagram let us see what happens this is it is intact this intact this line will remain as it is no change okay.

Now there is swap which is happen so line this was going up from this point should come to the bottom so this is come from here this should come to the bottom of this line and this switch has come down so this switch also has come down so this is connected from and this is going out okay so this particular line actually I will become the cross line from bottom to the top okay this line will become the cross line.

This particular line will become the parallel one I think now the similar excise has to be done here and these two have be gone up so bottom one is the common thing so this one which has gone up will come to th3e bottom one this which is now down the bottom up is I can take care of this one is now down from here has to go to the top one okay so I can transform it to this thing I can now even rotate the switches I told you I can rotate the switches.

So I will rotate this one so that this two taking care of okay I will rotate this one I will rotate this one and I will rotate in this case I will rotate not the whole switches I can rotate only the output part in this case I will rotate the output part the output part to make it okay so this is the output once which are being rotated and here the switches are rotated, and for this one switch are not still changing the wiring the states are equivalent.

So we will end up in a configuration which will be because I have to straight this so the bottom part must be connecting to the top part of this particular switch the top part will become the bottom and connecting to this part so the top part is connecting as it is so both have been rotated this bottom part is connecting to the bottom part okay in this case also is not the switch but the output which should be rotated actually.

So these tow remains as it is so here the output has been rotated so this will come here actually connected in this passion and I will rotate this one this output go it is out okay so this bottom will connect with this and this will go with this and this is a configuration so with one single connection whatever way you want to set up you can always transform it to this particular state so I defined this as the based state for single connection.

You can try out any other combination and this will turn out to be same let us do for another connection so let us do it here on this side. So I have build up a switch. Okay so I am not actually going to draw the remaining thing and maybe I showed actually so that you can understand what happens with the twisting and transformation so you can set up any other connection if you wish so I can set up something like this okay let us see what all transformation will be required so normally you can need not do it one step I have done it in one single step okay so from here I have got something on this side and then from there I have done.

So I have done twisting actually of the switches here for initially I did the translation movement of the switches so all of them come in the bottom. So I can do both the things simultaneously also so we will do in the same fashion first of all we will do the translation of switches then we will look at the rotation of the output for the whole switch outputs or inputs so that I will ultimately end up in this particular configuration so I have to essentially have this and this okay once you do that you will end up in a configuration which is like this.

So you will have the top can we do this top one so this also has gone down so this bottom one will be coming switch and then this go to the top and goes out. Okay and so remaining connection now has to be made given side here for this one has to be from the bottom side okay it is stop part is connected to this one this actually has gone up so top part is connected to the bottom one the bottom part is connecting to the bottom part of this that is why it gets distorted in the sense, not symmetric, and next step will do the rotations, so this has been done, this top bottom part, top part goes to the top, the bottom part has to go to the top of here, so the bottom part here goes to the bottom and this one has gone, so the bottom, this one top part to bottom, bottom part to bottom here.

So you're able to transition from here to here, now you have to do all the rotations to, instead of the whole switch, and come up with something as good as this, so this could be done, so you will twist this one, output side, you can twist this whole switch, this remains as it is, this remains as it is, I can twist this switch whole, I can twist this whole switch, I can twist the outputs here, rest everything remains the same, and I should get up that particular thing.

And you can see these all are common cells, so once I do the twisting, I will get, so the top connects to this one and the bottom connects to, so this goes straight at the bottom, so this one here, so I ended up in getting the same switch, so you set up any single connection, you will end up in this state, so we define this as the base state. We call it as state one, so from state one, I need not bother about when I do the second switch, second connection, what will be the new state.

Because all this single connection states are being merged into this, so I have to only bother about it and now set up the second connection, look at all possibilities and figure out the only equivalents between them. So I'm now merging all the equivalents states into one single state and there were number of states are restricted to very limited value, and therefore it becomes very easy to build up a state diagram, a state transition diagram.

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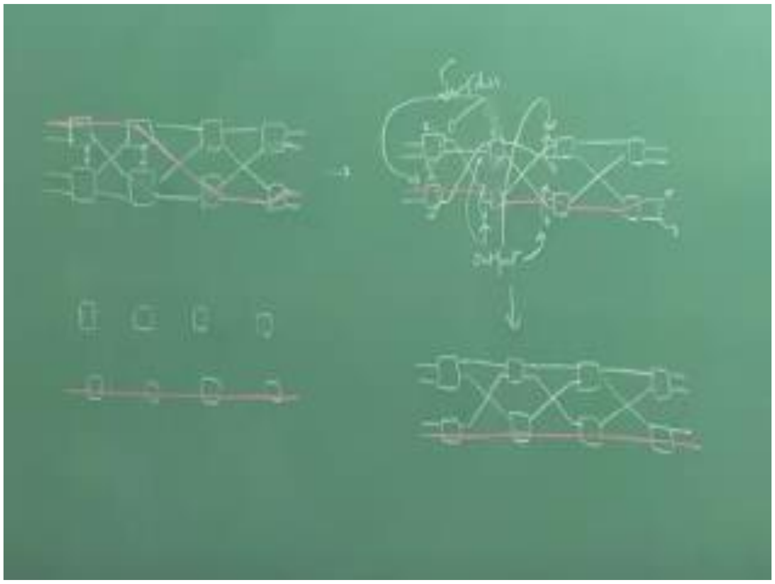

And what I can do that, I can identify which states are the blocking states and with what operation, I will be able to block them, I will be able to avoid that blocking state. So let’s do setup a second connection here and see what will happen. So what I will do is, I will now create the whole diagram here, state transition diagram, but every time for figuring out the equivalent states, I will be looking here.

So once we have this connection and you have, I will be using a few more colors for clarity and hope you should be able to see the blue color, I will try drawing it and if it is not visible, I will do it with the different color, so let me see how we can set up the connection, input coming from here, here or here, so what I will do is, I have to do very systematically, so I always try to actually setup the connection as far as possible from the bottom most input to the bottom most input first and then bottom input to the topmost one.

So this side I'm going from bottom to top, and this side also from bottom to top, and alliterating with all possible combinations and then trying to find out the equivalences, with two connections, if I find all the non equivalent states, so all equivalent states can be taken care of and from there I have to only look at the non equivalent state. So I have got only one non equivalent state here, all states with one single connection are being represented by this.

So, the state transition diagram becomes far more easier, so let do the connections, from here if I want to set up a connection, how this will be going, this will go up naturally, analyze as I said that I like to always go as far as possible, I can trying going towards the bottom or I can start going towards the up, I will actually go towards the up, so that I can match with the nodes and verify it.

So if I go up, so I will be going up, means going here, coming here and then of course, I wanted to connect to this switch, I can connect it in two different possible ways, I can actually always go up and therefore, now I cannot go up and then connect to this switch, I have to go to bottom, so I can connect this one configuration. So this could be one possible non equivalent states, but I have to look at other possibilities also.

Let me create over those and see what will happen, so there is another possibility, which I can draw here, and let's see whether these two, where equivalent or not, so second possibility is, it can go like this, oh I cannot actually have an connection to this one if I go downwards, so it does not matter, it has to go to straight to second one and then only this connection can be made. So I have exhausted all the possibilities from this to this.

There is no other possible way this connection can be set up, so now let's keep this input and now alliterate and go to the top, so if I go to this or this does not matter, both are same, so if I set up a connection from here to here and when I set up a connection from here to here, both are going to be the same states of the switch, so only one of them need to be considered.

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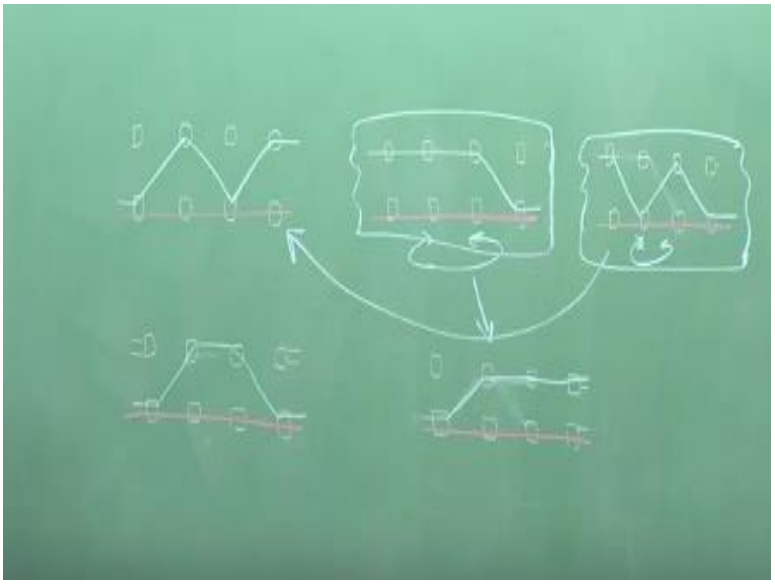

So let see how this can be done, so if I go up then actually I can try going this way and set up a connection. So perfect, this is another possible state, I'm actually going to find out every time new non equivalent state, I will put it, so the first one is this, so far I have not got, I cannot actually transform, by any way by rotating the switch or moving here and there whatever I did those transformation cannot come from here to here actually okay so this is the second possibility what could be the another one let see, so we can have, so next possibility goes up it goes down it goes up oh this is the way also I can make the connection from here to here.

Now can I actually by doing translations or anything can I move it here possibly I cannot there is only one common switch through which the two connection are moving here the two in different sets here it is in first and third stage so this certainly cannot be equivalent actually. So this is a different configuration then this one.

So what are the other possibilities let see ,so I actually draw a first connection so now I have already exhausted from this input from all possible output these two does not matter outputs so far it is reach is here it’s okay, so now I have to look from the top this one so let see what are the combinations which I can get I can try going actually first of all from the top side I can connect to this switch first so how I can do it I can go straight and connect .

But you can clearly observe if I actually twist around make this as inputs and these as outputs I will end up in this particular configuration okay so these two are the equivalent states so I can actually now bounded this a equivalent state to this one let's look at the other possibilities ,so i wanted to connect to this but I actually went straight first and then tried can I know go straight first ,and then can I go down and make the connection I cannot possible if I come here I have to go here .

So I cannot do it this way so now I am existing all possibilities now this is one possible option ,but amazingly you rotate this you will end up in this particular configuration so this is also an equivalent state to that so far we have found only three non equivalent states now let's connect from here to here and see how many non equivalent states are possible .

Okay so if you do it now so connecting it in this fashion so I have actually made the connections remember here from the top one to bottom one and I found in both possible ways I am actually coming back to already discovered states so now go from top to top let see what all states I can make .so I can actually go straight that's a one state thing there is no way probably I can actually come to this state.

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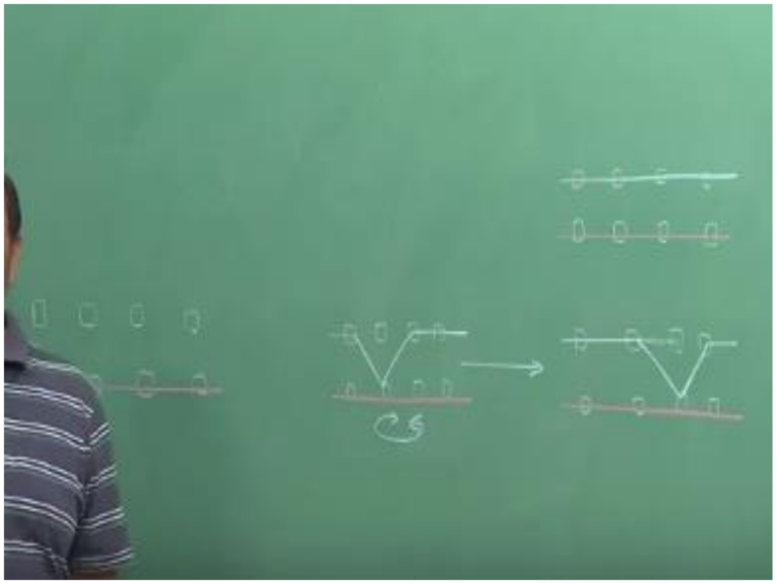

Okay both inputs and both outputs are from different switches in the input and output stages okay so this certainly is another possibilities then can I try different roots going from bottom and doing it so remember I am actually look exhausting all possibilities and where ever it is turning out to be equivalent thing I am just not considering if the equivalent already has been discovered.

So I can try now going this way to bottom no is not possible to set up so I can try this way now amazingly these three state which have discovered earlier they actually had 2 inputs going from same switch in the input stage this is not happening in this case so this certainly cannot be equivalent to those, there is no way I keep by any transformation I can move from here to there, and this also certainly is not equivalent to this.

So look at other possibilities still I have not exhausted everything i have to now look if I go to bottom what will happen so searching this time I actually go from here to bottom so I cannot go parallel I have to go here only way I can go it in this fashion but you turn it around you end up in this state okay so you will have I have now exhausted all possibilities for the second connection.

So only valid, only what we call non equivalent are with 2 with 1 connection is this one with2 connections I have now five possibilities 1 2 3 4 and 5, all other states with two connections can be assumed to be represent by any one of these 5.

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