Fundamentals of Industrial Oil Hydraulics and Pneumatics
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Lecture no 28
Module no 07
Logic Circuits

Now welcome to the lecture 28 which is on logic circuits, this is also under the module fluidics and fluid logic. In last lecture we have already given hints about the logic circuits along with the detailed discussion on the devices. In this lecture we shall consider 1 or 2 circuits to understand the logic circuits in a better way.

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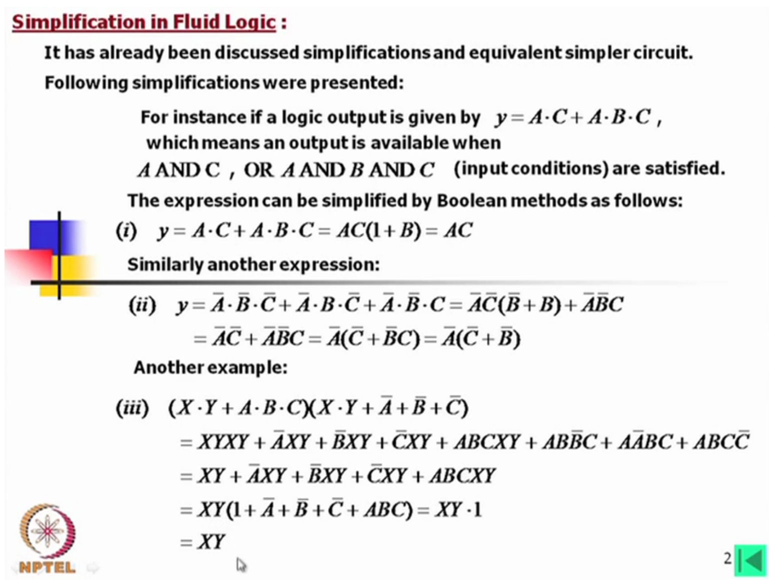

Now what last in lecture what we have seen that many functions can be simplified for instance, if a logic output is given by y = AC + ABC that means A AND C OR A AND B AND C that can be simplified to simply y = A AND C. Similarly, another expression what we took that such a big function that also can be simplified as NOT A AND NOT of C OR NOT of B, also the 3rd example was on that X AND Y + that is OR A AND B AND C the whole into again X AND Y OR NOT A OR NOT B OR NOT C can be represented by simply X AND Y.

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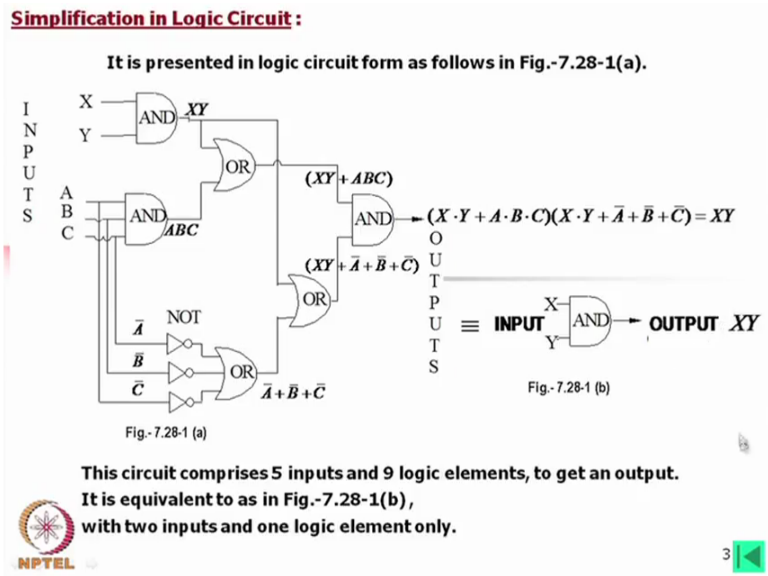

The circuit, look at the circuit here I shall I can discuss a little bit about the circuit, say remember this function X and Y so input X and input Y we put first allow to pass through an AND device output is X AND Y or XY. Similarly, we have put A, B, C these 3 inputs in another AND gate, remembered these gates may have 1, 2, 3, 4, 5 inputs in that case the same AND gate but here 3 inputs and here 2 inputs, also I would like to mention the same this gate also can be used here, only the say anyone of them there is no input, it is not connected to input, remember this thing the same device also can be used here but we have separate devices for 2 inputs, 3 inputs, et cetera.

Now here in this case output is ABC, now again it is possible that this we can directly connect to 3 NOT function NOT devices because if you remember this is the equation then what we are doing again this we are connecting through this OR okay. This function this output we are getting here, now we are getting this output here and this output here so again we passed through an another OR gate to get the total function as an output. And what we have done here, this output we have allowed through an OR gate and this output we have allowed through the same OR gate as the 2nd input and we have got this output.

Now what we need to do, this and this so we have used another AND device to get this function, that means now what is actually we have to say these are 5 inputs, now then these are describing their different conditions, sometime this and this, sometimes this and this, sometimes this and this and this is coming and then this or this and sometimes NOT of that that means NOT of that means signal 1 and 0 none of them is there that is connected to OR and then finally we get this output, so these were our our basic functions.

Now definitely here we are going through different conditions to get this function, it might be say this is a large machine system where these functions are performed to get this output but it might be these functions are being used for some other performance, only when we would like to get this output we can simplify this, how? This circuit already 5 inputs I have told and 9 logic elements, how 9? 1, 2, 3, 4, 5, 6, 7, 8, 9 to get this output to get an output is equal to XY output is only this much. Then this can be replaced by input is equal to XY and output and it is through AND gate and we are getting this output.

Or in other words, say suppose say these are being used from some other functions but to get this output simply we take this output directly because what we have seen through simplification we can simplify to this but this is an arbitrary function we have taken we have taken this output okay. So it is like that, this is one part of the machine it is performing something and one part of this machine is performing something then finally what we do when this total function is required, simply take this output. With 2 inputs and one logic element only we can solve this.

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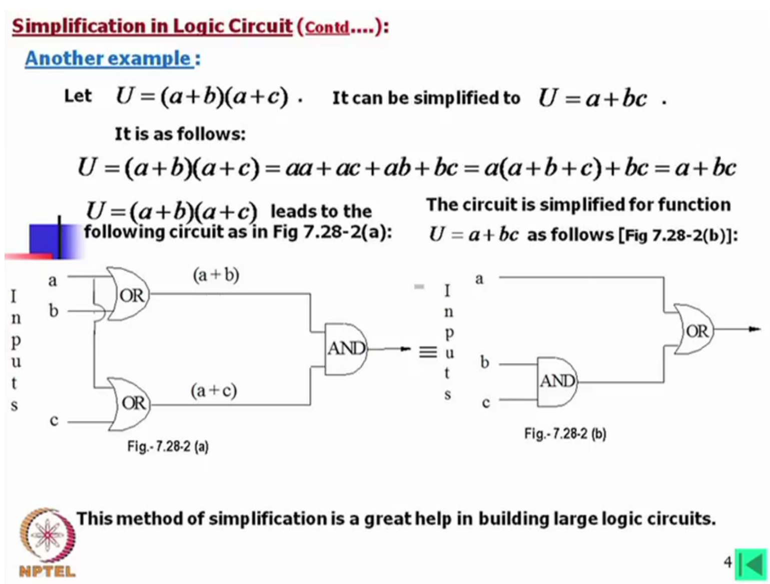

Now this another example which I have also shown you, this is U = a OR b AND a OR c this can be simplified U = a + b + c that this simplification is shown here, while we are simplifying you can see this first steps are normally the general algebra like things then we take a common, still it is a general algebra, but after that we will find a + b + c = 1 it has to be or in other words whatever the value of a this will be there. If a = 0 safer example, a + b + c three are 0 in that case this will be 0, if let us consider a = 1, in that case if you just write a this will be 1. Suppose a = 0 but b = 1 and c = 0, in that case still this will be 0 so whatever the value of a always this will be equal with this one, so for this part it is the Boolean algebra you have to take care of that.

Now in device, if we have to make a circuit following all these steps here then 1^{st} of all what they will do, we will take an OR device with A and B input and then another OR device where A and C are the inputs and then finally we pass it through AND gate and this must be equivalent to that here B and C through AND gate and A is through OR gate okay, simply this function the output will be same. This method of simplification is a great help in bui's and being many local home Railroad Avenue Road refresh newly curvilinear different results are very lding large logic circuits.

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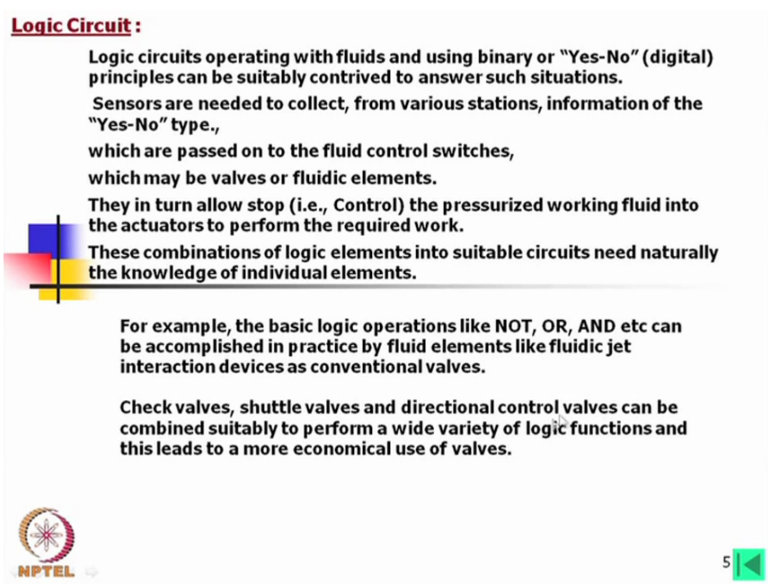

Logic circuits operating with fluids and using binary or "Yes and No" principle can be suitably contrived to answer such situations. Sensors are needed to collect from various stations, information of the "Yes-No" type okay. This means that I would say that whether a function is No or Yes, we should how we can know? That usually these are collected through sensors, which are passed on the fluid control switches which may be valves or fluidic elements. They in turn allow stop that is control, they pressurised working fluid into the actuators to perform the required work. These combinations of logic elements into suitable circuits need naturally the knowledge of individual elements.

For example, the basic logic operations like NOT, OR, AND, etc can be accomplished in practice by fluid elements like fluidic jet interactive devices as conventional valves. Check valves, shuttle valves and directional control valves can be combined suitably to perform a wide variety of logic functions and this leads to a more economical use of valves. Now here I would like to mention that while we are describing fluidic devices, we told clearly that fluidic devices has no moving components and from that definition we told that direction control valve, the check valve, pressure valve which we use in fluid drives are not logic devices are not fluidic devices. However, using those valves you can develop logic circuits also, so do not be confused this when these are being used to make a logic function logic circuit but these are not fluidic devices.

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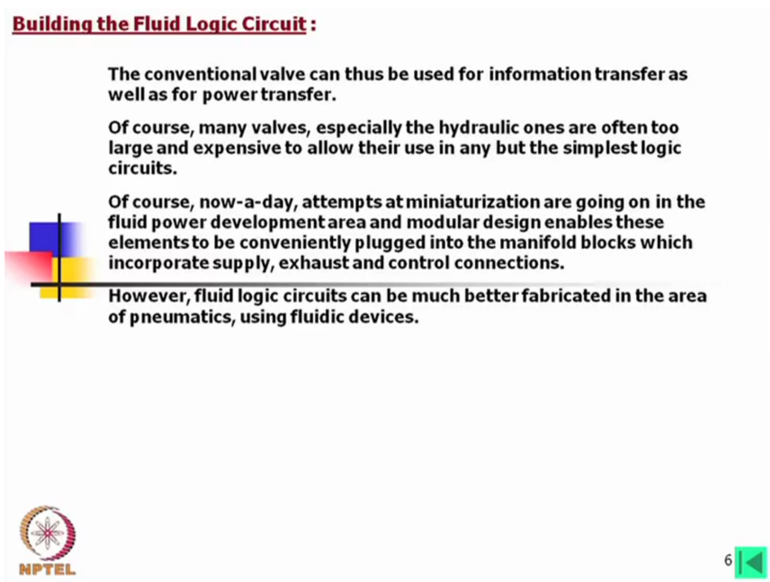

The conventional valve can thus be used for information transfer as well as the power transfer. Using these valves logic circuits one advantage is that these powers can directly be used, not much amplification is required. Of course many valves specially the hydraulic one are often too large and expensive to allow their use in any but the simplest logic circuits. Suppose if we would like to use we can use these hydraulic valves to make logic circuits but normally it will be expensive and may become bulky okay. So maybe you may find that where the fluidic fluid logics are being used for the hydraulic circuit also, you may find that circuit this logic circuit party may with fluidic devices and then that is connected to hydraulic parts but you can make with hydraulic part as well.

Of course, nowadays attempt of miniaturisation are going on that means many hydraulic valves, many hydraulic components are made very miniature form to make such circuits, but many cases I would say those are expensive and not much beneficial and that can be plugged into the main manifold for the performance for the output. However, fluid logic circuits can be much better fabricated in the area of pneumatics using fluidic devices.

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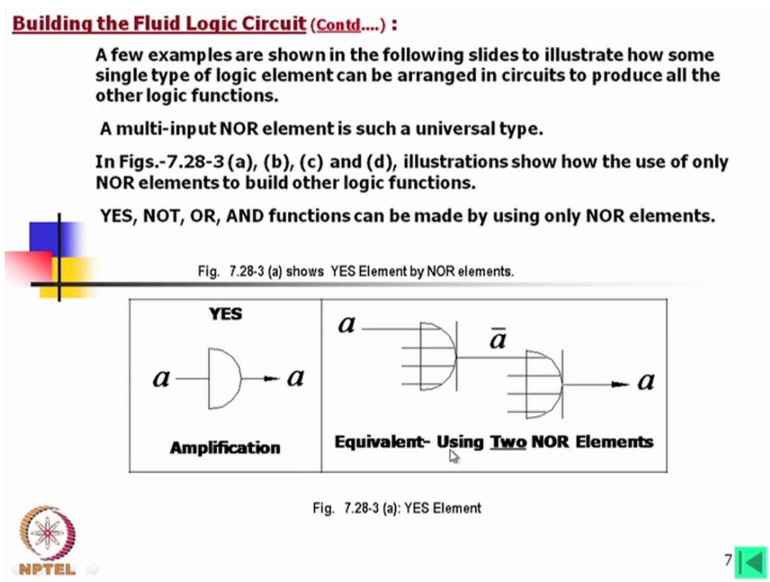

A few examples are shown in the following slides to illustrate how some single type of logic elements can be arranged in circuits to produce all the other logic functions. Here is an interesting thing, now multi-input NOR element is such a universal type NOR element has a very special role in fluid logic or so to say in logic circuits. Now in this figure a, b, c, d I will show you now that will illustrate how the NOR element can be used to make other logic devices. Say here we will see we will go through that YES, NOT, OR, AND these 4 functions or these 4 gates can be built only by using NOR element, this is NOR element you remember this thing.

Now first take there is an YES element we have already learned this is a YES element application element okay, now this can be made by NOR elements. We have put a you see this NOR devices like that, this is a this looks like D and then vertical bar and then output that means if a input is there then output will be a bar that we know and here we have seen that this is multiple input, this device is usually you will find that if you think of the electronic devices this is very simple, small element you will find so many input only one output, in case of fluidic device also you may find there are 3, 4, 5 inputs and then one output. So we have taken such a device, we do not have these device but we have this NOR device. Now you simply connect another NOR device in front of it and you will get this output, so these 2 combining is giving this YES get so this means that this YES can be made by 2 NOR elements, let us take another.

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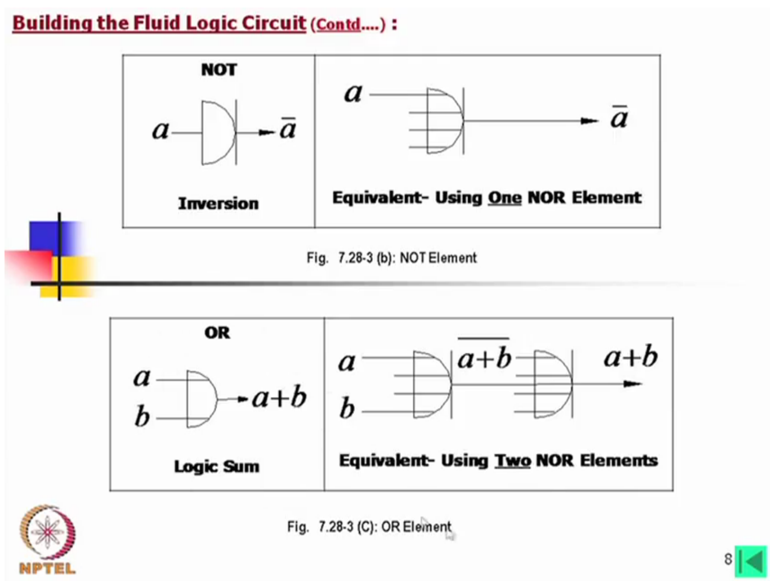

This is a NOT NOT gate, now this also can be made by NOR, simply that use the state, this is NOR gate in a sense NOT OR so OR function must be there so there will be multiple inputs, difference between this and this one is that this is a NOR device and this is only NOT device. NOT devices having only one input and one output inverse of that, NOR gate is having the input and say multiple inputs and then the NOT gate of that, now using such a NOR gate and with only one input we can get the NOT get, this is very simple but this can be done.

Now let us take this another case, this is OR element and in some OR elements you will find that this is extended up to this point, it can be ended here or it can be taken up to this point, maybe there are some standard international symbols are there which we are not using but let us look at this how this can be built by NOR elements, in that case we have taken 1 NOR element say a + b we are getting this output a + b bar, then what we did, this whole output we are taking through another NOR element that means this whole output is put only into a single input of this device to get this one, so again we have got this gate using 2 NOR elements.

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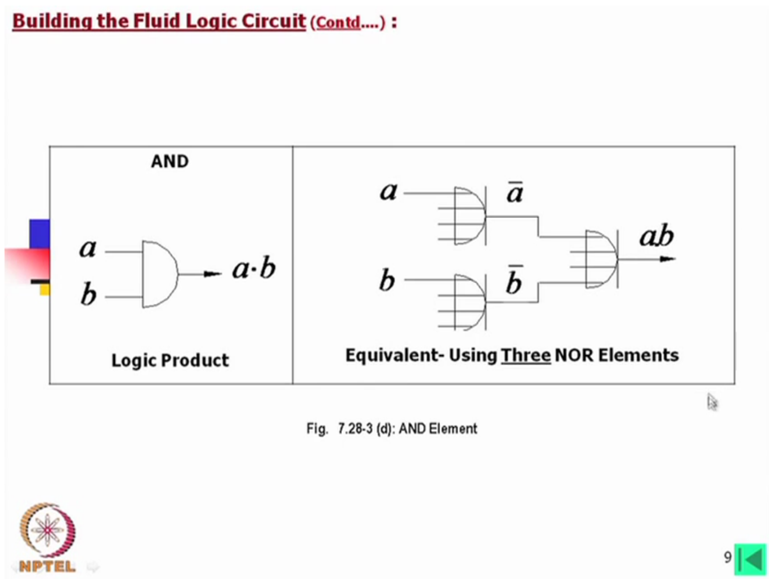

Now we will take an AND, in that case what we have done, first we have used a NOR device to get a NOR and then we have taken another device to have b NOT, now these two a NOT and b NOT be have taken to have but here we should remember that this is a bar b bar which is giving this a dot b dot so in this case we will find that some Boolean algebraic taken otherwise, this will be a bar b bar, no this is you can say this is 3 NOR elements so a bar b bar and then reverse of that will give bar and a dot b dot, this is a theorem is there, you see this is not a + b by bar, it is a bar + b bar.

Look at this, suppose a = 1 then a bar = 0, b = say 1 then b bar = 0 then a bar by b bar = a bar + b bar = output is 0. Now that also you can get a dot b, now let us consider a = 0 so this is 1, b = 1 so this is 0 so a bar + b bar = 1, now a dot b will give the same result so you have to just go through this exercise to get but this is mind it this a NOR element. At this stage apparently this output is a bar + b bar, which again equal to a dot b dot.

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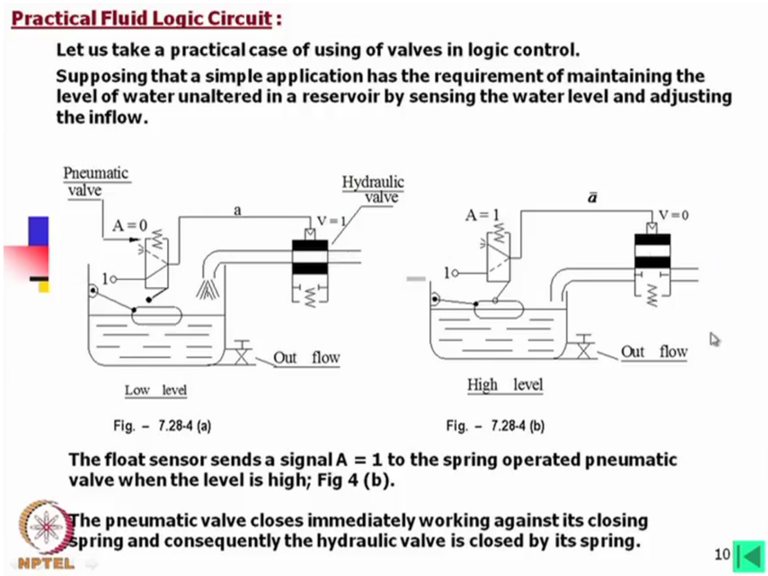

Let us take a practical case of using valves in logic control, in that case what we have supposing that simple application has the requirement of maintaining the level of water unaltered in a reservoir by sensing the water level and adjusting the inflow. Now what we have done in this case, let us see say this is a valve, what is there? This is the input and it is directly going through if the disturbance is not there, once the disturbance is there then this will be opposite to that and then there will be actuation of this one, so what we do then there is some disturbance that means this is moved than it is a NOT and this valve is being actuated. So it is like that, the water is when the water is being filled and it is touching this one then valve is being closed.

Now so to say you can see this functions, you can read it, let but one thing you should remember, in such cases you need some delay because if you think that when the water is filled then this valve is stopped then when the valve should start again, if the water level comes down and immediately starts operating then again it will go up and sometimes it is not desired, so it is like that when the water is coming down, it has to go up to certain low-level only then this valve will start, so it needs another delay switch which is not shown here. It is only as if shown that when it is filled then this valve is stopped.

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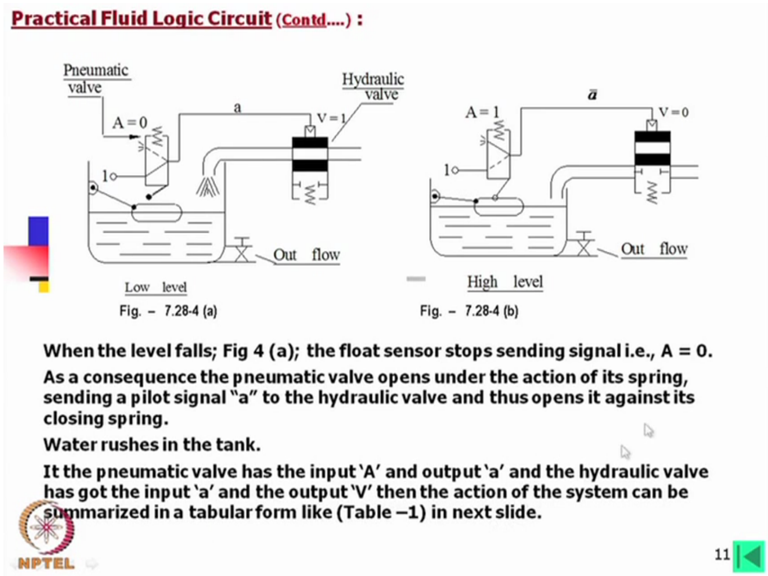

Here again the same valve we have now described here the logic function which I have told you. If the pneumatic valve has input 'A' and output 'a' small 'a' and the hydraulic valve has got the input 'a' and output 'V' then the action of the system can be summarised in a tabular form time showing here in the in the in this slide.

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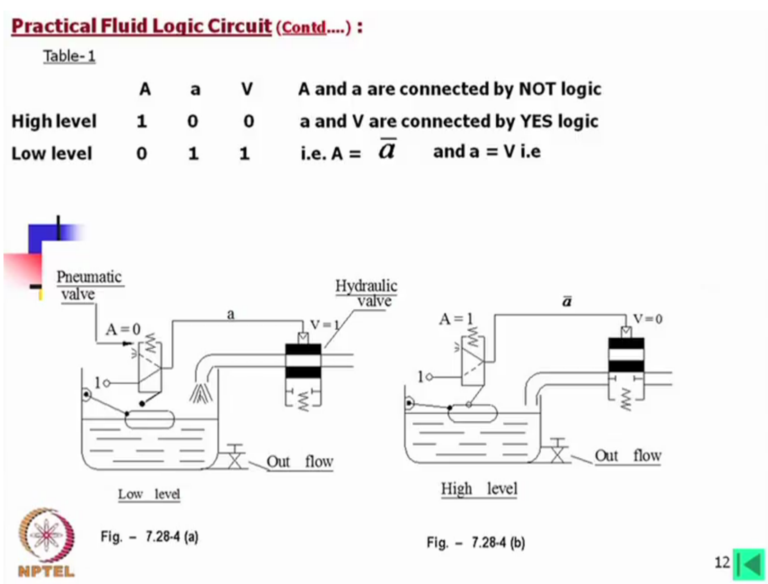

Now A is this device, A is the input and 'a' small 'a' is the output and then V is the input signal for the main valve. Now high-level A = 1 then a = 0 that is A bar then valve is also 0, 0 means here this is not functioning, when only this low-level this is 0 then a = 1 then valve = 1, so this means that A = capital A = a bar and a = V, these 2 functions. So if you had to make a logic circuits, you can make the logic circuit accordingly, but using these devices it is shown how this water level is maintained. But here again I would like to say that delay switch is not shown.

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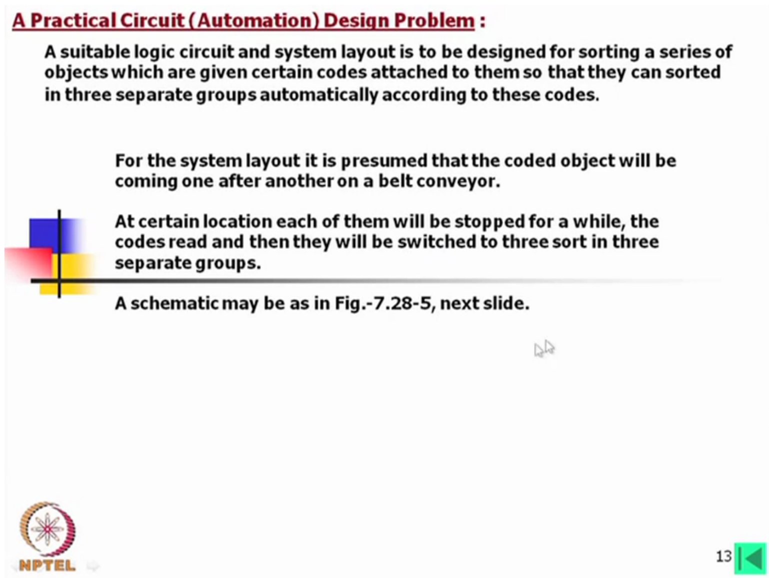

A suitable logic circuit and system layout is to be designed for sorting a series of objects which are given certain codes attached to them so that they can sorted in 3 separate groups automatically according to these codes. So here let us consider this is a design problem, the problem is like that we have a sorting machine or sorting conveyor say to say, an object will come then depending on what object it is we have to send it 3 separate conveyors. For the system layout it is presumed that the coded object will be coming one after another on a belt conveyor. At certain location each of them will be stopped for a while, the codes will be read and then they will be switched to three sorts in 3 separate groups. A schematic maybe as inthis figure, figure number 5 in the next slide.

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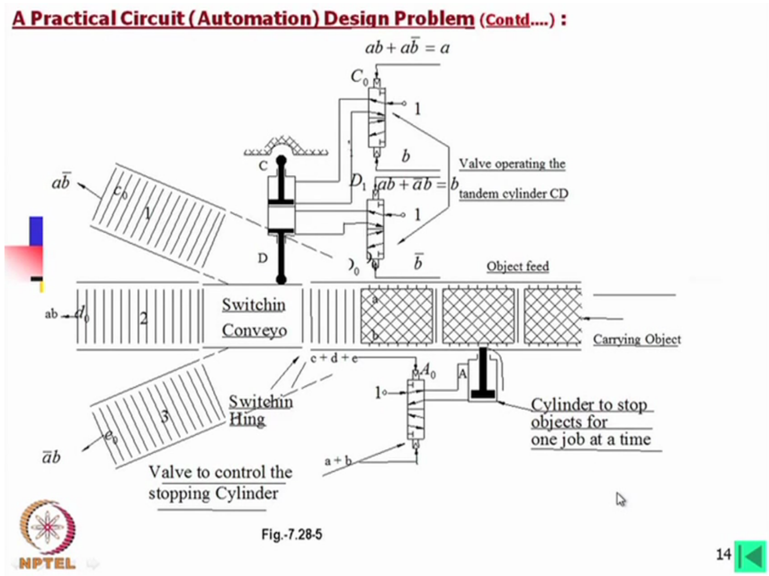

Now look at this, this is a real system in that case what we find there is a conveyor, this conveyor is moving right to left. Now on that conveyor the objects are coming from another source, sometimes it might be manually you are putting there or maybe from another conveyor it is coming together, say let us consider in a factory where the production they are coming the the finished products are coming into the main conveyor here and then they need to be sorted out, 3 different products are there, they need to be sorted out and they to be sent to the 3 conveyors.

Now it might be say 2 are the products acceptable products and third might be the rejected one, it might be in that way also, or depending on the size they are being sent to different conveyors, whatever may be it needs to be recognised whether these objects is say identical to the 1st one and or it is a different one, and again this should be recognised as if this is the 1st one then it should go to the 1st conveyor, if this is the 2nd type then it should go to the 2nd conveyor and if it is 3rd type then it is to the 3rd conveyor like this. So what is done basically, when the object is coming 1st of all what we should do? We must stop it and then we should recognise it that what it is, type recognition.

So definitely there should have a sensor which will recognise what object it is okay. Now while it is being recognised, so it should be held here it cannot simply pass there, after it is being recognised here then it should be sensed that or this information would send to the system which is diverting these items to different conveyor. Now you see these are the switching conveyors, these are this is a single, 1, 2, 3 what we have shown, this is a single one and this actually being pulled or pushed by this cylinder. So it is coming to this, there might have another conveyor or maybe a Hopper to collect this, it might be a conveyor or Hopper whatever it might be this is another hub, so this single component, a single part of the conveyor is being diverted to put into 3 different parts okay.

Now also what we should observe that here if we look into this cylinder, this is a double acting cylinder because this can move this way but this actuation only in single direction and this is only stopping the item, stopping the item. Whereas, if you look into this cylinder this is a special cylinder, in this cylinder middle portion at the middle portion is closed that means as if there are 2 cylinders, this can be constructed by simply taking these 2 cylinders and they are coupled in the reverse direction okay, so 3 different parts of okay. Now also what we should observe that here if we look into this cylinder, this is a double acting cylinder because this can move this way and that way but this actuation only in single direction and this is only stopping the item stopping the item.

Where else, if you look into this cylinder this is a special cylinder, in this cylinder middle portion at the middle portion is closed that means as if there are 2 cylinders, this can be constructed by simply taking these 2 cylinders and they are coupled in the reverse direction okay. Now this end of course is having a joint, 1 end is fixed to the reference frame, it can swing over there say you can imagine a ball joint is there, while this is being extended then this is also rotating this way or that way because this is a another fix point so when it is it is being contracted it is coming like this, and when it is being extended then again it is going in this direction so we need some ball joints.

And then these 2 Pistons are separate and that also in each chamber these are double acting. Now we have named this is cylinder A, this is cylinder D and this is cylinder C, A D C remember okay. Now these are these valves are you can say actually the logic devices are there but it might be as I told that ordinary hydraulic valve, basically these are pneumatic valves and the circuit are made using this ordinary pneumatic valves okay.

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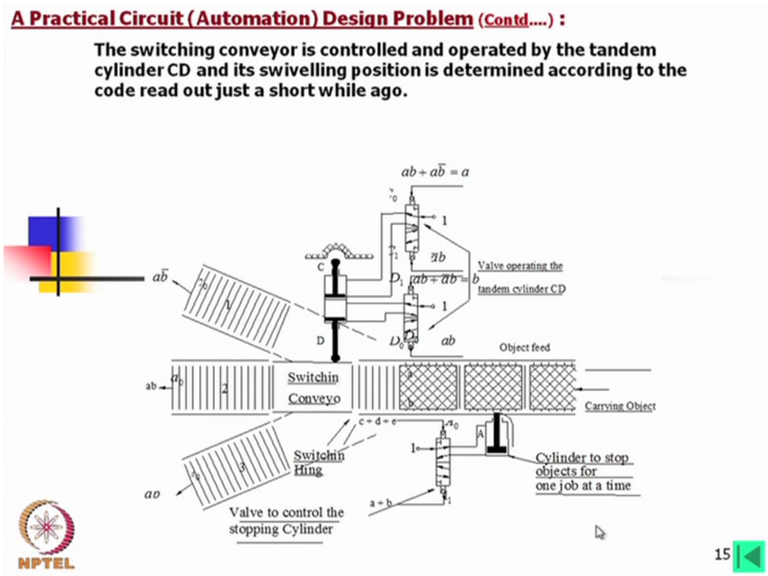

Now next we consider, the switching conveyor is controlled and operated by the tandem cylinder CD, this cylinder is called tandem and its swivelling position is determined according to the code read out just a short while ago. That means a code is read here, this code is a and b, we have to with the sensor we have to read this code, then with this code we can find out what is the object so that will be 1st recognised and then it will be sent this information will be sent to the next section. When the sorting of one object is completed, this stopping cylinder A retracts that means this will retract and will allow the next object to go through the sorting process.

That means this basically it is stopping here, now here actually the sorting process is there so objects are coming, one object here then this is stopping the other object so it is being recognised. Once the recognition process is over then this will be this will this will operate and it will go its direction and then this will be retracted and this will go here that means this conveyor is basically running and stopping run run and stop, run and stop, and stop condition one object is being held, another object is being recognised. And once it is recognised, again the conveyor starts, this is diverted and then another object comes it is like that okay.

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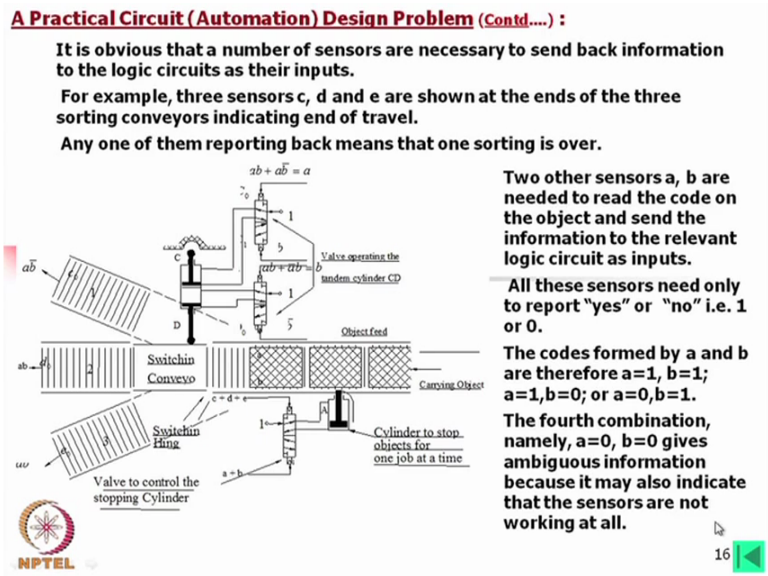

It is obvious that a number of sensors are necessary to send back information to the logic circuits as their inputs. For example, three sensors c, d, e are shown at the ends of 3 sorting conveyors indicating end of travel. That means we have the sensor here a, b sorry c, d, e these 3 sensors are there okay, this is the showing the sensor position nothing else but actually sensors are named as c, d and e. Now when the object is passing through this, then it is being sensed that object has passed so that information is going into the main logic circuit okay.

Anyone of them reporting back means that one sorting is over that means once this is passing this is already passed then another sort is covered over so immediately this will go to the another conveyor. Say for example, the items two consecutive items have same identity, that identity is a b bar and this is perhaps a bar b, this is not coming so we have to check it. That means here the sorting is like that one is a b, 1 is a b bar one is a bar b, these three sorting are there. Now let us consider 2 items consecutive items is having a b bar identity then it is like that.

When this is passing through there this conveyor only then this will allow to enter here and this means this is allowing to enter here means this is running so the object which was stopped here, it has now come here. And suppose 1st item was here and 2nd item was a b so it will go there but by that time another will come over here. Two other sensors a, b are needed to read the code on the object and send the information to the relevant logic circuit as inputs. All these sensors need only to report yes or no that is 1 or 0. The codes formed by a, b and therefore, a = 1, b = 1; a = 1, b = 0 or a = 0, b = 1, if these 3 codes are there okay. The 4th combination namely a = 0, b = 0 gives ambiguous information because it may also indicate that the sensors are not working at all.

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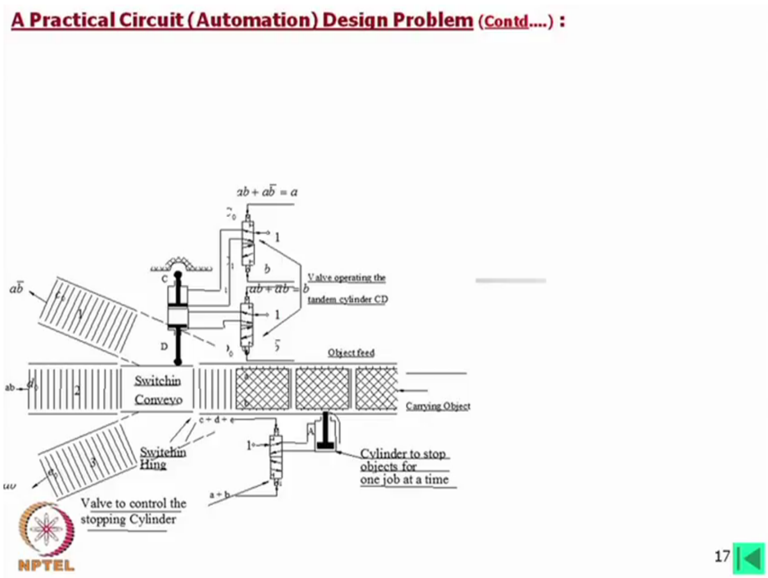

So whether a = 0 or b = 0, you have to show should some devices then this is not an object, either or maybe sensor is not working something like that. In a similar way, the tandem cylinder must be able to work in 3 different ways. Now you see what is there if you look into this logic, we are not going into the detailed development of this logic here but it is a + b + ab, a + b OR ab then this is actuated. You see how this will be operated, if you look into this a + b, a + b = a, in that case this signal is there that means this is being retracted and or that one ab + a bar b = b, in that case this is also retracted so that means we are getting this is a fully not fully extended, this side extended and this side not extended so this is the middle position only.

And when this is retracted and this is also retracted then we are getting this position whereas, is these 2 cylinders are fully extended, only we are then getting this position, these are operated by these functions a, b dot already it is decided, once it is decided then these functions are performed, once these functions are performed we get these operations. That we will see, this mathematical part is not being shown in this slide but we will feed is how the logic circuit looks like. If extension is indicated as 1, retraction as 0, the three positions would be for different combinations of C and D okay.

Now it is like that, C D that is we have named this cylinder A, B, C, D. C and D this is 0, the action is that position 1 leading to sort conveyor. Now this is 0 1 or 1 0, position 2 leading to another sort conveyor, and position 3 leading to sort conveyor, I mean this is position 1, position 2 and position 3, this for this combination position 3 we are getting this position 2 for this combination. You see you can see position 2 is having 2 alternative position, say this is retracted, this is extended or this is retracted this is extended so that is why for these 2 conditions position 2 will be available, position 1 is available only when these 2 are (())(45:33) Position 3 will be available when these 2 are fully extended.

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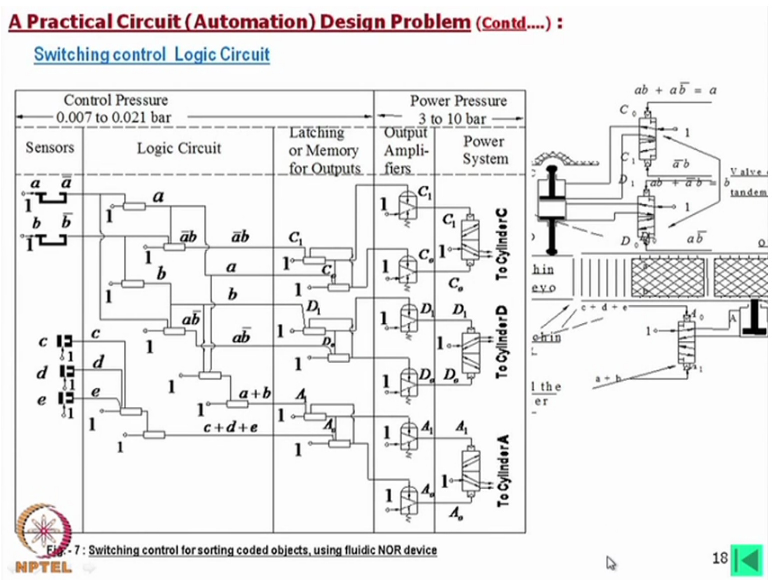

Now this circuit look at this circuit, I understand it is very difficult to draw this circuit but if this circuit is shown to you, you must be able to recognise what the function is being done and what is the possibility. Now look at this, these are the sensors say this is a then a b bar say it is like that, in this sensor this input will go through this and then this is the logic circuit, in that logic circuit 1 input is there and output is 'a', then this is b okay. Now here in this what we are getting, 'a' is coming over here and here getting a bar b through this output then a bar b is coming over here and here a bar b and here 'a' is coming from there again it is going to b.

No, this b is going there, 'a' is it is now coming it is being fed to here so here we are getting a + b and here we are getting c, d, e, this is the stopping condition here. Now from there we are getting c, d, e, now this is the latching or memory output, now here I would like to mention that there is we require a memory device, memory device why we need it because as I have told that 1 when the 1 performance is not completed we should not have the another performance but that is not possible only by AND or OR gate or NOT gate, we must need a memory device so that memory device is associated with AND, OR, etc, gates.

So unless one performance is over the another performance will not be performed. So here this memory devices are put over here and then this is output amplifier, it is going to that C 1 and this is going to C 0 so if this operates and then this will not operate that means these are to operate the cylinder either retraction or full extension condition, similarly for D 1 and D 0 and similarly for A 1 and A 0. Now this is I would say this is a very complicated circuit in that way, so to understand what you should do, you should take this picture and this picture together to understand what is being performed.

Also you will find that we need to go through another exercise to understand the circuit in detail way that might be in some other lecture but out of these instructions what I expect that looking into this will figure and this figure, you have to understand how the operation is being done one after another.

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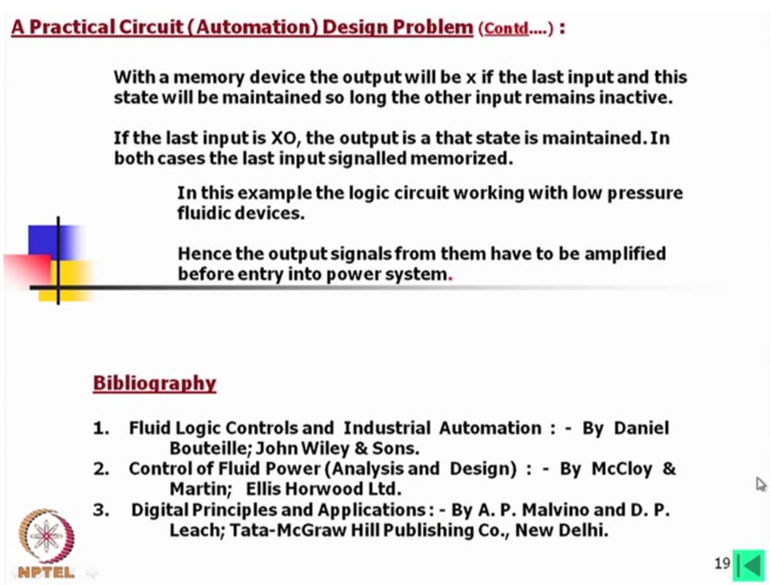

With a memory device which I have mentioned, the output will be x is the last input and this state will be maintained so long, the other input remains inactive this is also true for the water level. If the last input is X = 0, the output is 'a' that state is sorry this this is confusing, 'a' is the output here, that state is maintained, in both cases the last input signalled memorised. In this example, the logic circuit working with low-pressure fluidic device, the circuit which the last circuit was shown that was with logic fluidic devices. It is also possible to make it with the electronic devices hence the output signals from them have to be amplified before entry into the power system.

That is obvious as I have told, if we would would like to use the same source for actuating the cylinder, we need to have some amplifier there which are not shown in this circuit. Now this is I suggest the book, The Fluid Logic Controls And Industrial Automation, to follow this book but I do not think this book will be available in the market, but there is also some you may go through this book Digital Principles And Applications this is published in India, this book may be available yet. Whereas, this book is to have a general idea about the fluid power devices, so thank you.