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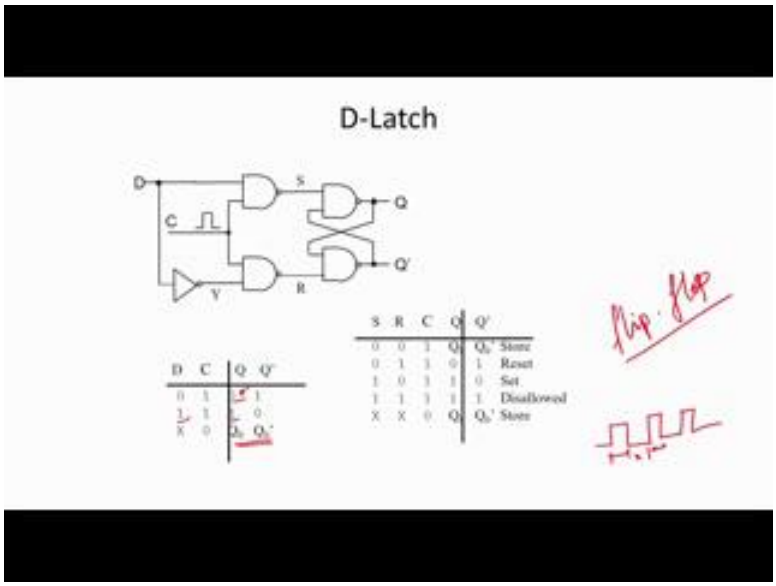

So, this is the basic building block of our latch S R latch and with the help this thing we can construct some of the other latches or other flip flops. So, when we talk about it is clock then we use the term flip flop also. So, when we talk about latch then at the particular time that control clock signal is not here, but when it is clock then we say these are flip flop also. So, we can construct those particular flip flop, with the help of these particular basic S R latch with control input.

Now, in this particular case what will happen you just see that here we are having two input S or R. So, in that particular case what happens what we are doing one is the complement of the others. So, if it is D is 1 then other is your 0 and if it is 0 and other is 1. So that combination 11 is totally avoided. Now, it won't go to any race condition. And if you look into the behaviour then what will happen? When control input is not there then whatever may be the D value then it is going to retain my previous input. So, when D value is 0 then output is 0, when D is 1 output is 1. Basically it is D is 1 output is 1, D is 0 output is 0 you can analyse it with the help of this particular table then in that particular case we say this is a D flip flop. Why we are going to say D flip flop you just see the behaviour whatever input we are giving it is coming as an output in the next state. So, after some delay it is appearing as my output; that means, when clock signal is arriving so, we are giving a continuous clock signal. So, when clock signal is present at that time whatever input we have it will be transferred to the output Q and during this time we are doing nothing again this point we are giving it the information.

So, whatever input we are giving it is reflected in output through some delays this delays depend on the propagation delays of the components that's why we say this is a D latch or D flip flop or delay flip flop, this is one.

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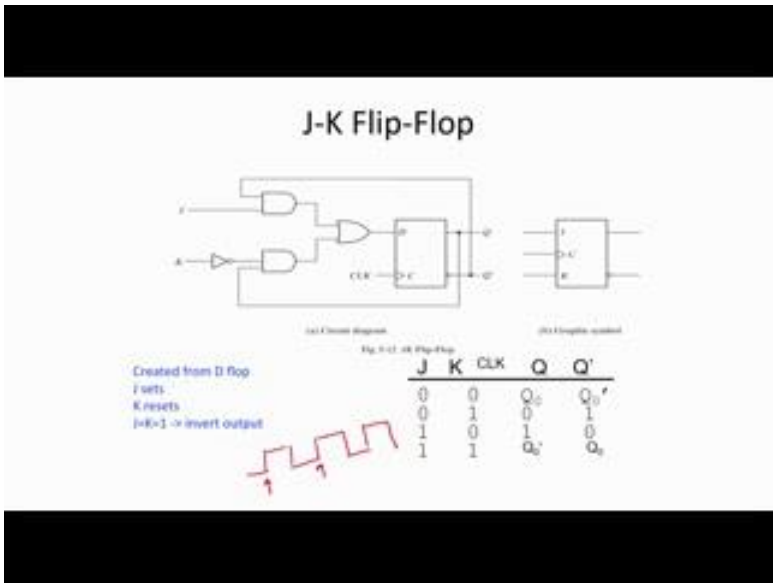

So, another one we are having JK flip flop so again it is constructed we can construct it with the help of D flip flop here we can provide this J and K. So, just see the behaviour it says that if J and K are 00 there is no sense of the output, if it is yours J is 0 and K is 1, basically K represent for reset we are resetting it so output is 0 and when it is your 10 J is then for your set; that means you are setting it, output is 1 and when it is 11 at that particular point the output toggles, if it is Q then it will become $\bar{Q}$.

So, if output is 0 then it will become 1 if output is 1 then it will become 0. So, this is another building block we call JK flip flop. So, we can control it with the help of this input signal J and K and along according to the values of J and K we are going to have the output over here. So, one is your no sense, one is your toggling the output and other two combination one is your set, other one is your reset. So, we can retain the information at the output till the next clock arrives. So, we are having a continuous clock over here.

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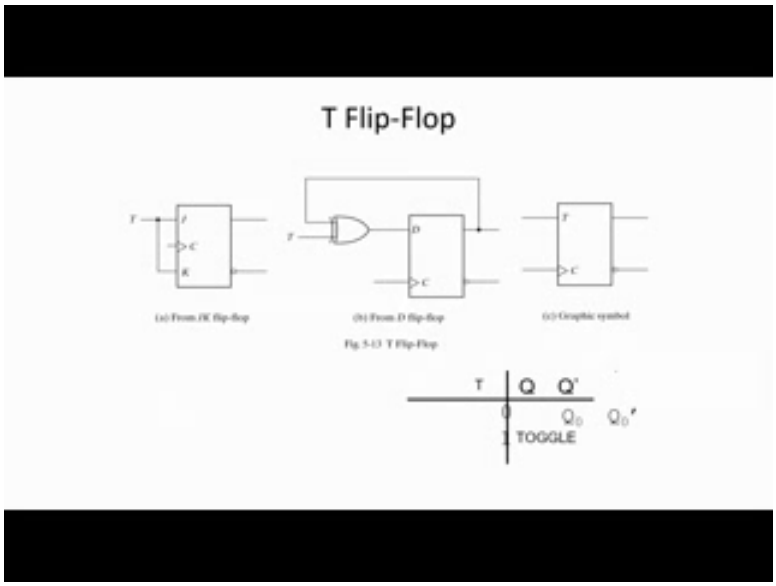

So, another one we are having T flip flop which is your toggle. So, this is very simple from constructing from JK flip flop you just see that when both the input is 1 then what will happen it toggles basically if output is 0 then it becomes 1, when it is 1 then it becomes 0. So, we tied this particular J and K to one symbol input. So, if T is 0 we don't have any sense in the output when T is 1 then it basically toggles. So, this is another building block. So, these are the storage element flip flop. So basic one is your RS latch, from latch we can construct our flip flop and basically we are going have three basic flip flop one is your D flip flop, second one is your JK flip flop and third one is your T flip flop. With the help of this flip flop we can construct some other flip flops also. So, we are not going to discuss about it, but with the help of this flip flop we can now, construct our storage element.

Now, along with that we are having two more signals called one is preset and one is your clear. So, these are basically asynchronous input when we are coming about asynchronous input; that means, we are having another type of input also which is known as your synchronous input. So, in case of synchronous input what will happens, say here when I am giving sending my input J and K when output is going to get sensed it will be synchronised with the help of an clock signal, when there is a clock signal arrives then during that time output senses. So, this is related to this particular control clock and we say this is the synchronous behaviour. Now, if you are using two flip flop to keep two bit of information if it is a synchronous circuit then what will happen output is going to get sensed simultaneously when the clock signal is here and in case of asynchronous signals what will happen as soon as my signal is coming

irrespective of the clock signal it is going to sense the behaviour of the output. So, say that I am going to consider about a longer clock period.

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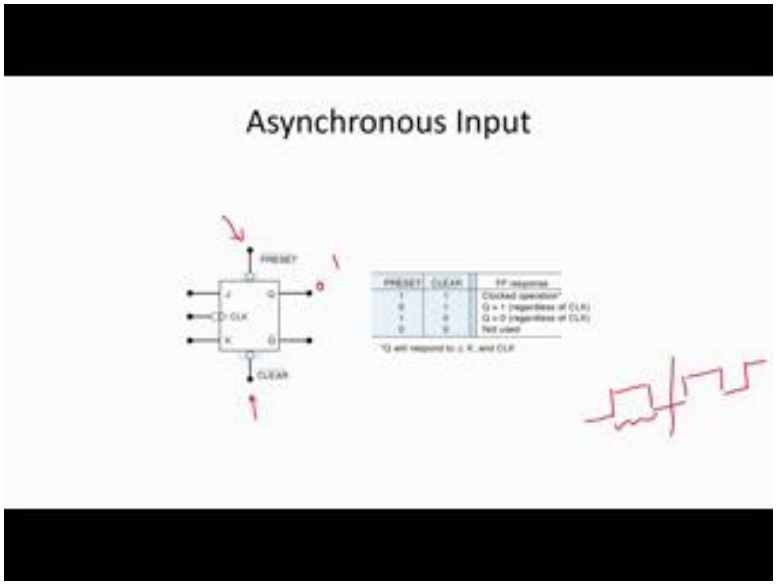

So, in that particular case say in case of synchronous if this clock is there then only output is going to get sensed but if some input is coming over here there will not be any sense in output. But in case of this two asynchronous input preset and clear irrespective of the clock signals it is going to take immediate effect and accordingly it is going to sense the output. So, these are used to either set or clear this particular flip flop.

So, we are having storing some information, but at some point of time I want to clear it then as soon as I give the clear signal over here then what will happen the output will be 0 it is clearing the information. And as soon as I am giving the preset signal basically we are going to set the value to 1, so you say this is the presetting a flip flop. So, it is irrespective of the clock signal whenever this preset signal will come what will happen that Q bit will be set to 1, so that‘s why we are saying asynchronous flip flop because while constructing our circuit sometimes we will be needing this particular clearing the information or setting the information to 1. Now, with the help of this particular flip flop we now, we can construct some of the basic building block. One of the basic building block is your registers. What is a register basically? Register is a device electronic circuit where we can store information.

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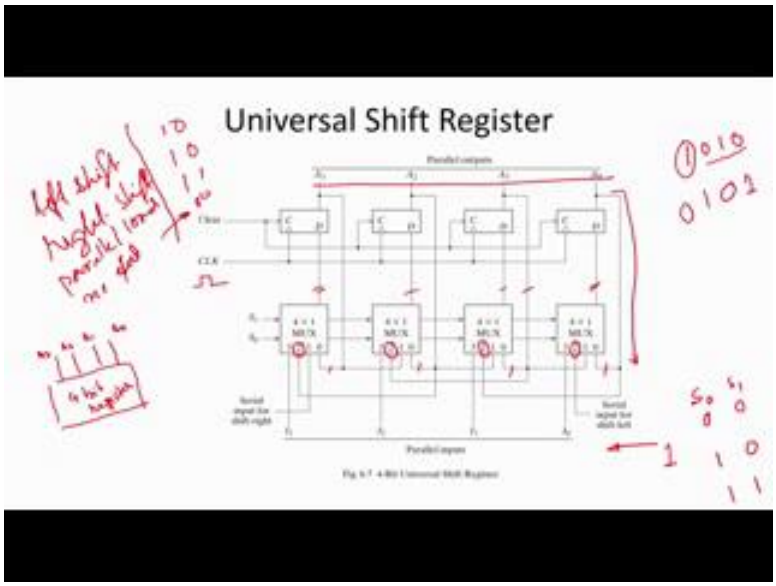

So, in that particular case if I am going to say that I am having a 4 bit register, then what will happen we are storing 4 bit of information and whenever required we are going to take it to the output line say A_0, A_1, A_2, A_3. So, we storing some information now what is there in this particular register? Basically we are having 4 flip flop according to our requirement we are storing the information in the flip flop and after that whenever it's required we are going to take this particular information. So, here we are going to talk about a universal shift register. So, basically this is the register with the help of this register we can store our information and we can perform some operation and we can take out our information whenever it is required.

So, give me a diagram of 4 bit universal shift register. So, what happens basically? It is having four operation one is your shift register we can shift the information either towards right or towards left. So, one is your left shift second one is your right shift and another information we are having parallel load we can load the information parallelly. So, 4 bit of information we can load it parallelly and whatever information we are having these are available always in this particular output lines. So, these are basically D flip flop these are the Q point of this D flip flop so these are always available.

Now, you just see what is there basically now I am saying that we are having three operation left shift, right shift, parallel load and along with that we can say that no effect. So, whatever information we have always these are retained. So, for that now, we are having four operation we need to perform. So, for that what happens we are using a 4 × 1 mux depending on the

input scenario we are performing this particular, giving one of the input as an input to this particular D flip flops. So, say this 4 × 1 mux we are having four input selection and we are going to select one of this particular input and putting it into the output of the mux. And how we are going to select it? We are going to select it with the select line S0 and S1. Now, just I am going to consider one particular input you just see this particular signal this output is directly connected to 0 this output is connected to 0. So, all the outputs are connected to 0; that means, whenever I am giving that select line as 00 these input lines will be transferred to this output lines of the mux and that will go as an input to the D flip flop and whenever clocks arrives then what will happen that will be transferred to this thing. That means, you see that we are retaining that information over here; that means, that no effect will be given by this particular control signal S_0 and S_1

Now, just consider one particular things. You just see about this particular input 2. Now, what is happening in this particular things we are giving a new input and whatever information we have over here this is coming as an input to the next D flip flop. The output of this one is coming to as an input of this things. Now, what will happening say initially if I am storing say 1010 say we are retaining it. Now, whenever I am giving the input as 10; that means, 10 and I am selecting this particular 2 signal then what will happen whatever input I am giving it is coming to this particular input signal and it is available over here. Now, from A0 whatever output is here it is coming as an input to the next flip flop. So, now, this is basically transferring the information from A_0 to A_1, A_1 to A_2 and A_2 to A_3.

So, basically 0 will come over here, 1 is come over here and 0 will come over here and this one we are not keeping anything. So, this is 010; that means, these 3 and whatever input I am giving input 1 then it will become 1. So, in that particular case say whatever we are having we are shifting this information towards left. So, it is now, new information will come this one we are not storing anywhere. So, this shift at 1 bits towards left and the new input is coming to this particular serial input. So, this 10 combination is going to give me your left shift operation.

Similarly we can have the right shift also just see the behaviour and you can find out the control signal and whenever I am going to give 11, so, basically that left shift we are going to get that 10 so here right shift will be 10. Now, when you give 11 then what will happen you just see that this third input line of mux will be transferred to the output of the mux, ok and when clocks arrives then that will be stored in this particular D flip flop so that means we are parallelly loading this particular input to this particular register. So that's why we say this is a universal

shift register we can perform the shift operation as well as parallel load or we can retain the information also as long as we require it. So, this is a 4 bit. So, if you need an 8 bit then what will happen? Now, we can use 8 flip flop and 8 mux. So, to store our information in our computer in our processor we use such type of register.

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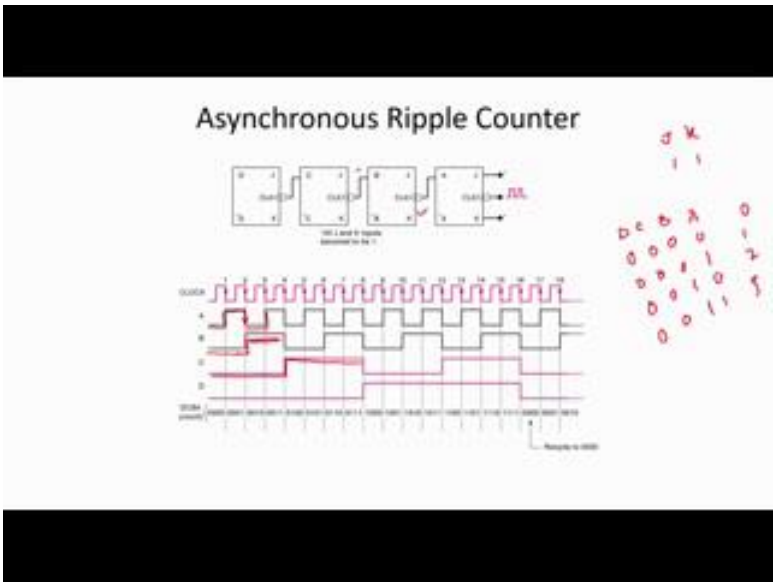

Another one it is called counter. So, this is the ripple counter we are having. Now, what basically it is having you just see that we can say that this is the continuous running clock and as soon as the clock is coming then what will happen the output is going to get sensed. Now, what basically it says that here we are going to put 11 as J and K for all the flip flop; that means, that JK flip flop is going to act as an toggle flip flop T flip flop. Now, what will happen say $A\ B\ C\ D$, initially say we are resetting it say all are 0.

Now, what will happen when this clocks arrives then what will happen input is going to get sensed over here depending on this particular behaviour. So, as soon as this clock arrives then what will happen that A is going to get toggled, so it will become 1. Since this is remain as 0. So, all will remain as 0. So, this is the behaviour you just see that when clocks arrived that A is going to get it from 0 to 1, but it will remain 0. Now, whenever is next clock is coming you just see that again it is going to get sensed, but now since this clock is available now, now, this B is going to get sensed. So, now, when this signal is coming over here then I am going to get 0010.

Similarly when this is coming. Now, 1 it will remain as 1. So, there is no sense in the C block. So, it will remain as 0 and next clock coming it is 11. So, we are going to have such type of behaviour. So, this is the number if I am going to look for these things this is 0, 1, 2, 3. So, it is going to have that going to give us counting effect we can count our numbers. So, this is another circuit. So, in details we are not going to discuss it; and why we are going to say this is asynchronous because all are not controlled by same clock signals they are going to controlled by different clock signals. So, this clock is coming out from the first flip flop. And when this signal is going to get it sensed from say 1 to 0 then this flip flop is going to get effected it will go from 0 to 1. So, all are not synchronised by the same input clock they are synchronised by different or they are a operated by different signals clock signals so that is why I am going to say this is asynchronous counter.

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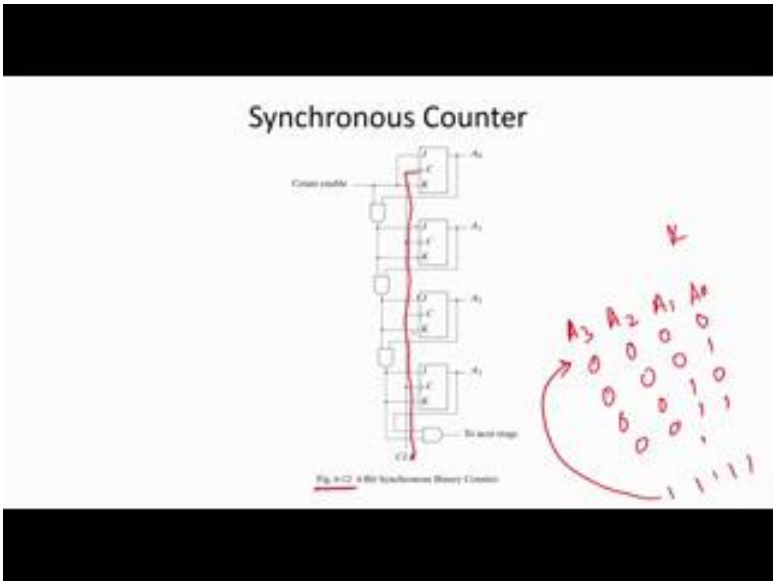

Similarly we are having that synchronous counter you just see that. Now, here we are giving the same clock to all the flip flops. So, again it is a 4 bit counter I can say that A_0, A_1, A_2, A_3. Now, you just see how you are setting J and K over here, depending on that you are going to get the behaviour initially if all are 0 then when first clock come comes then it will become 001, next clock comes it will become 0010 then 0011 like that it will go and finally, all are will be 1 and again from 1 it will go to 0.

You can analyze this particular circuit and we are saying this is your synchronous counter because all the flip flops are control by 1 common clock and I think here you can see this things

that some figure 6.12 is coming basically I am taking this particular diagram from a book of digital design by M Morris Mano and this circuit counter circuits are explained in the chapter 6. So, you can go for this particular chapter if you want to have some details of analysis of this particular counter.

But here we are just simply talking about informative purposes only in knowledge level we are going to use counter when we are going to build our computers. So, this is the some blocks of your counters.

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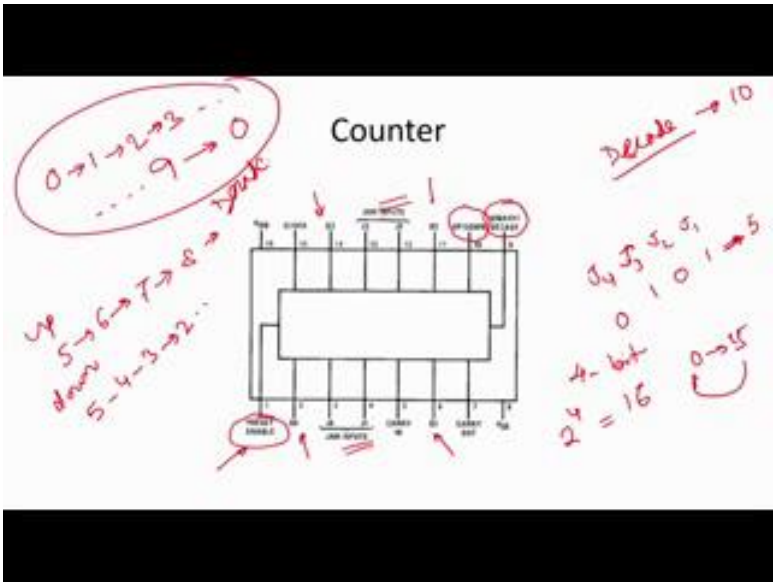

Now, what will happen you just see that here I am having some of the input signal one is your $UP/DOWN$. So, it is a counting up or counting down. Ok along with that we are having some input also that means with the help of this input we can preset this particular counter with the help of this particular $PRESET\ ENABLE$. Now, just see that if I am going to give say these are J_1, J_2, J_3, J_4. Now, in that particular case if I am giving 1001 and I am enabling this particular preset then what will happen? We are going to set this particular counter to 0100 and this outputs are basically these are Q bits these are outputs. So, in this counter we are going to get output as 0100.

At that particular point I think you are having slight idea about binary number system and decimal number system. So, in that particular case I think this is your decimal 5. Ok In next class we are going to see about more details about this things.

Now, when I say that this is an up counter then what will happen it is going to count from 5 6 7 8 like that in case of up counter, when we set it as down counter then it is going to do the countdown basically going to 5 4 3 2 like that. This is the down counter. So that means we can preset the counter to some initial value from that we can count up or we can count down also. Along with that we are having another one called control signal called $BINARY$ and $DECADE$. I think you know what is decade, decade stand for a particular decade; that means, it is 10.

So, if it is a safe binary counter it is a 4 bit counter what is the different combination we are having in 4 bit this is your 2^4 which is equal to 16. That means, it will count from 0 to 15 and come back to 0; that means, we can have a counter for 16, 0 to 15 and coming back to 0 when we are going to use as a binary counter. But in case of decade counter what will happen we are going to restrict the count to 10 only 0 to 9, when as soon as your 10 will be coming then again will be reset to 0; that means, we can count the decimal number 0 to 9. So, what will happen it will count from 0 1 2 3 like that it will count up to 9. Then what will happen? When after 9 in case of binary counter it should go to 10, but now, here again it will be 0 1 2 3 like that. So when you set to as a decade counter we are going to count 0 to 9 again reset to 0. But when it is a binary counter then we are going to count from 0 to 15 then again 0. So, this is a counter that we are going to use in our circuit.

So, here what will happen, we have discussed some of the building blocks that will be used in our computer and what is those building blocks we are having two type of building blocks one is your combinational circuit second one is a sequential circuit; in case of sequential circuit flip flop is the main building block. With the help of 1 flip flop we can store 1 bit of information. So, if we need to retain more bit of information then we are going to use more flip flops. And two basic building blocks we have discussed over here one is your register, registers are nothing but the storage element we can store our information with the help of an n bit register we can store n bit of information. Another one, counter it is basically going to counter sequence from 0 to n, if you are going to look for an n bit counter then what will happen if can count from 0 to 2 the power of n if it is in binary counter, but that counter can be configured for other counter also like that we have discuss about the decade counter.

Ok so these are the basic building blocks that we are going to use while going to construct our computer. Now, just see some of the test item of questions. So, first question I am saying that what are the main characteristics of digital system and analog system.

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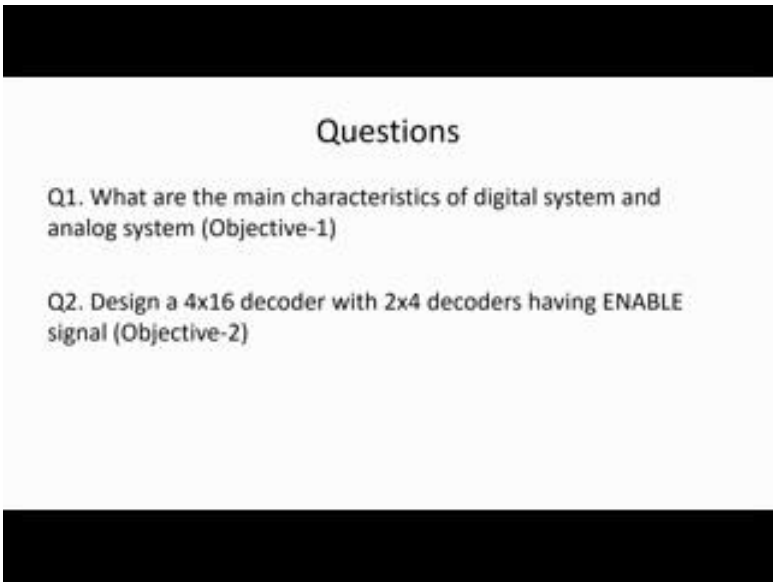

So, already I have explained about it digital means discrete it is going to work from discrete signal. So, we have mentioned some of the objectives. So, this question is related to the objective 1 of this particular unit.

Second question I am talking about design a 4 × 16 decoder with 2 × 4 decoder having $ENABLE$ signal. This is meeting the objective 2. So, construction of some digital building blocks. So, already I have explained one example I think I am constructing a 3 × 8 decoder with the help of 2 × 4 decoder. Now, we are asking to construct 4 × 16 decoder with the help of 2 × 4 decoder. Just first you think how many decoder will be needed to construct this one, you have to be correct one if you are going to get the right number then drawing diagram is a very simple one. So, you have to find out how many 2 × 4 decoder will be needed to 4 × 16. So, four fours are sixteen, but I can tell you that it is not four 2 × 4 decoder, ok this is not the correct answer.

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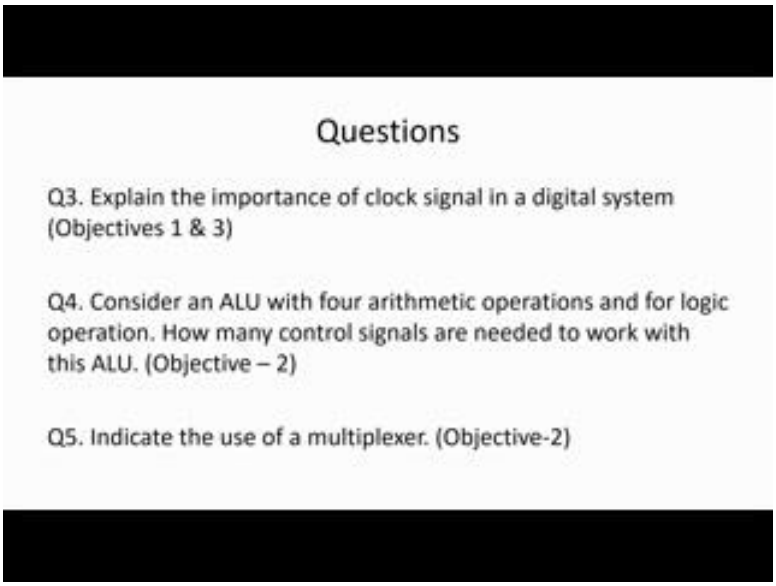

Third one I am talking about explain the importance of the clock signal in digital system. So, this is objective 1 and 3. Basically, in case of your sequential circuit it may be synchronous and asynchronous we need the clock signal. So, you just look for the importance of this particular this clock signal when you are going to design any digital system.

Question 4, I am giving like that consider an ALU with four arithmetic operation and 4 logic operation. How many control signals are needed to work with this ALU? I think I have already explained these things in my lectures you can go back to that particular portion and you can get it over there.

Question 5, indicate the use of a multiplexer. So, you know what is multiplexer we are having several signals, now you want to select one of them only that can be done with the help of multiplexer. Like say in question 4 this is a use of my decoder. With the help of decoder we can select one of those particular operation. Now, you just think where you are going to get the use of multiplexer that we are having several input and we are going to select one of these things. I think already in our lecture we have used somewhere multiplexer maybe you remember it, while going to look for the designing of our universal register. I think we have used multiplexer over here. Now, you look for some other example where the multiplexer will be used. So, with that I am going to wind up this particular unit.

Thank you very much.