Electrical Measurement And Electronic Instruments
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Lecture - 48
Background: From Flip Flop to Counters - II

Welcome come again, we are studying the second part of this course which is on Electronic Instruments. And, as a background we have started studying some discussion on basic electronics. So, in the last class we have studied starting from SR Flip Flop.

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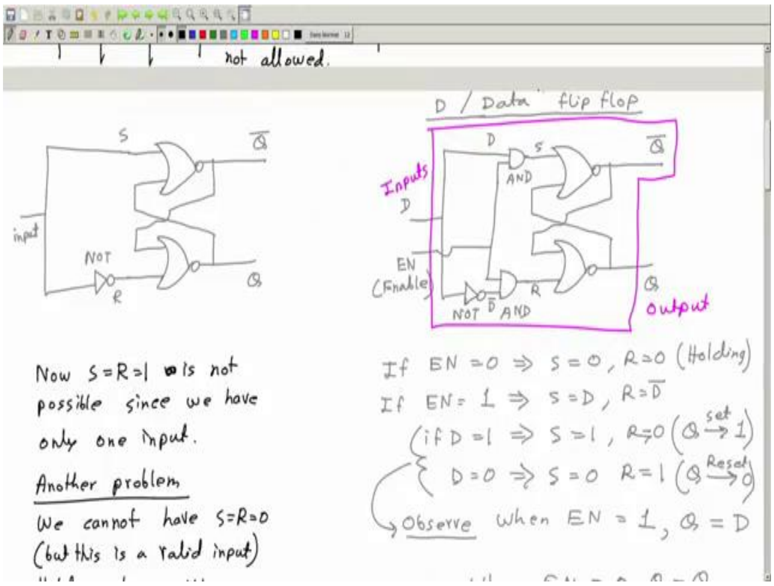

Then we have studied D flip flop.

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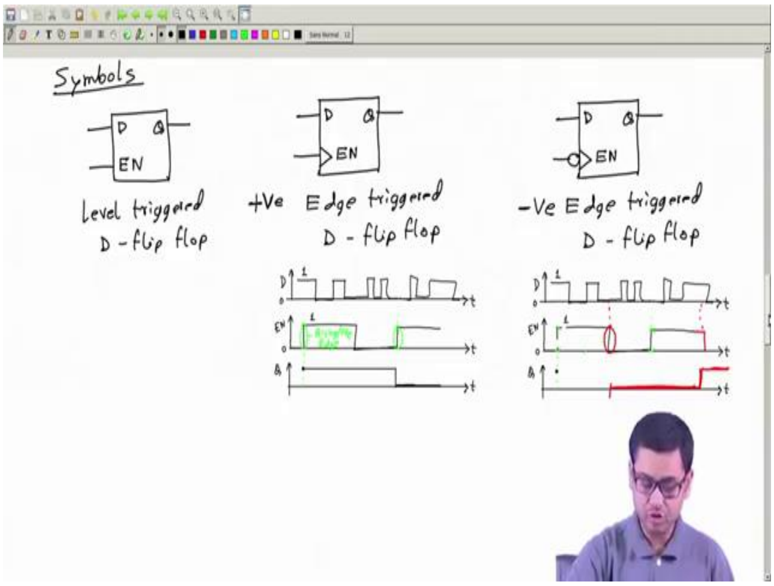

Then, after that we have studied two variants of D-flip flop, level triggered and edge triggered ok.

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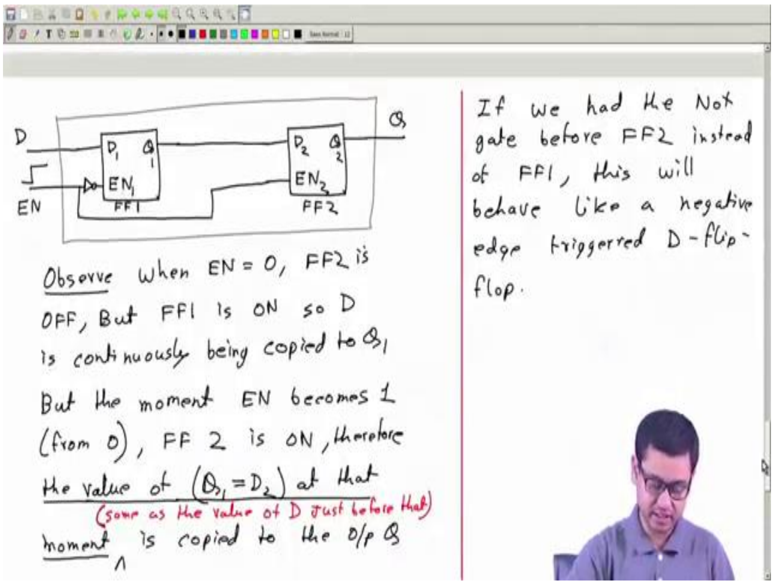

So, and then we have seen a circuit called master slave circuit for an edge triggered D-flip flop.

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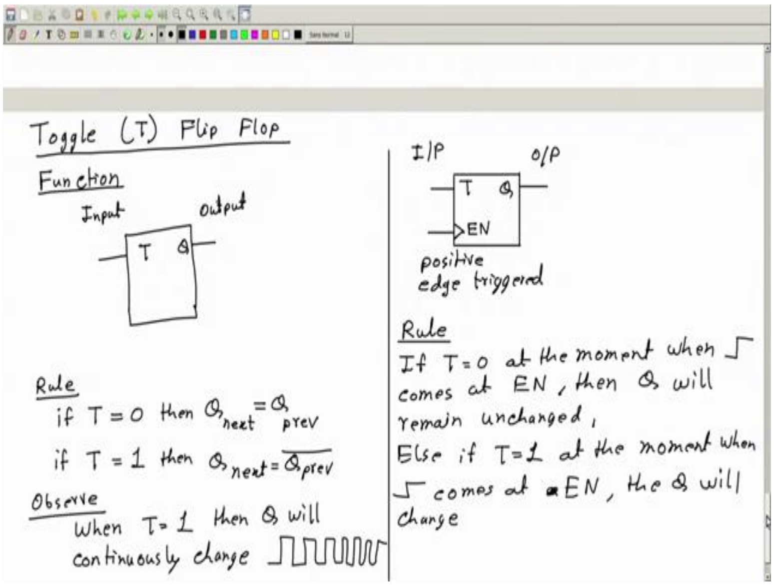

So, after that today let us take another flip flop, which will be very useful for further studies it is called T flip flop; T for Toggle, toggle or T flip flop. What does it do? So, let us see first the function, then we will see the circuit.

If T=0 then $Qnext = Qprev$

If T =1 then $Qnext = \overline{Qprev}$

Now, there is a small observation. So, in this case observe when T = 1, then Q will; that means, the output will continuously change, continuously oscillate, change or toggle ok. So, if T = 1, then Q will become from 0 to 1, then 1 to 0 and so on it will keep happening very fast continuously like this ok.

So, this type of T flip flop is therefore, not very useful. So, we need a small modification which will become useful ok. So, the modification is this, this is the T flip flop, it has input T output Q, we will have a clock enable EN ok. So, that so, these are inputs of course and this is the output, now this symbol, this triangle as I told you before represents a edge triggered input. Particularly positive edge triggered input, because there is no bubble before this. So, this is positive edge triggered. So, now, how will this device work?

So, the rule is that if, T = 0 at the moment when a rising edge. So, let me draw like this. So, this symbol means a rising edge, for is of writing I am using it. So, when a rising edge comes at enable, if T = 0 at the moment when this rising edge comes at enable, then Q will remain unchanged, but if or else if else if T = 1, at the moment when this rising edge comes at enable, then Q will change. So, what does it mean?

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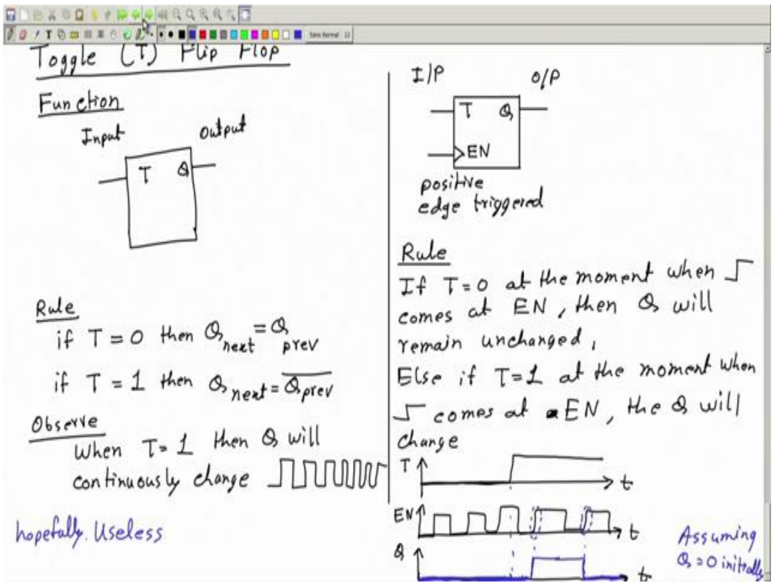

So, it means say, if I draw some timing diagram like this let this be time, then this is let this be the toggle T ok. And say T is varying like this. So, it is initially 0 from here to here and then say, it becomes 1 from here to here so, this is T. And if I have this enable like this say 0 1 0 1 so, this is how it is changing, then how will be the Q output so, let us see that.

So, this is the Q, now let us assume that Q is initially 0 ok. You can as also assume that Q is initially 1. So, whatever you like you assume. So, say I am assuming that Q is initially 0. So, here at this moment it is 0. So, assuming Q = 0 initially ok. So, then at this moment it is 0. Now, you see toggle is 0 from here to here. So, nothing will happen. Because, toggle is 0 no matter whether rising edge falling edge whatever comes at enable nothing will happen to Q, Q will remain unchanged. So, from here to here so; that means, up to this point nothing happens Q is exactly equal to 0 always ok.

Now, after that toggle is 1. So, now, Q can change, when can it change only if there is a rising edge at the enable. So, it is here ok. So, observe there is a rising edge here, this is not the rising edge this is the falling edge, then another rising edge is here. So, these are the instance where you can change, because T is 1. So, at this moment; that means, here Q will change will go from 0 to 1 and then here again it will change, it will go from 1 to 0, it will not change anywhere else, then it will remain 0 until another rising edge comes at the same time T should also be 1.

So, that is the rule for Q 2 change, for output to change, we need the toggle 2 have the value 1 and a rising edge should come at the enable P ok. So, this is the positive edge triggered T flip flop ok.

And, this T flip flop I mean this is useless I hope hopefully useless, I guess. I do not know whether this can be used. So, this is the T flip flop.

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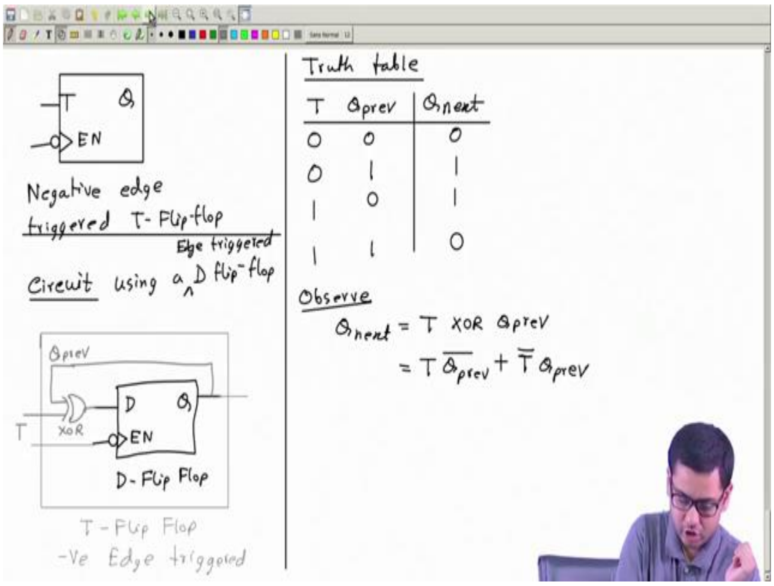

Now, so, similarly we can have another T flip flop, another type of T flip flop, which is negative edge triggered T flip flop, whose symbol will be just like this, we will have a bubble before the enable this is T, this is Q, input output. So, this is negative edge triggered T flip flop ok.

Now, let us see, how we can make this flip flop ok. So, we know how it functions, how it works; now let us see the circuit or how we can make it? So, we will make it using a D flip flop ok. So, if you recall we first started ha SR flip flop, then with SR flip flop we made a D flip flop, then with D flip flop we made a edge triggered D flip flop. And now we will make a edge triggered T flip flop using a edge triggered D flip flop ok. So, we will have this edge triggered D flip flop. So, let me first draw the D flip flop. So, this is D this is output Q and it has a enable call it EN it can be positive edge triggered or negative edge triggered whatever you like.

If I say take a negative edge triggered, I can take it no problem. So, this is a D flip flop edge triggered of course. Now, using this I will make a T flip flop how let us see ok. So, for that you just observed this rule or truth table ok. So, if now the input this T output is Q or call it Q next means of at the next moment after the clock pulse or clock edge comes at enable ok. So, this is input this is output, now if T equal to 0 output will be same as Q previous ok. So, let me also write Q previous ok. So, if Q previous is 0 out Q next will also be 0 and if Q previous is 1 Q next will also be 1.

Then, but if T = 1, then I have 2 choices if Q previous is 0, Q next will become 1, if Q previous is 1, Q next will become 0. Now, you see that this truth table is the truth table of a XOR function. So, we can write that Q next this is nothing, but this is Q this is T XOR Q previous, which you can also write T Q previous bar or T bar Q previous right. So, when they are unequal then the output becomes 1, if they are equal 0 0 or 1 1 output is equal to 0.

Q next = T XOR Q prev

$$= T\,\overline{Qprev} + \bar{T}\ Q\ prev$$

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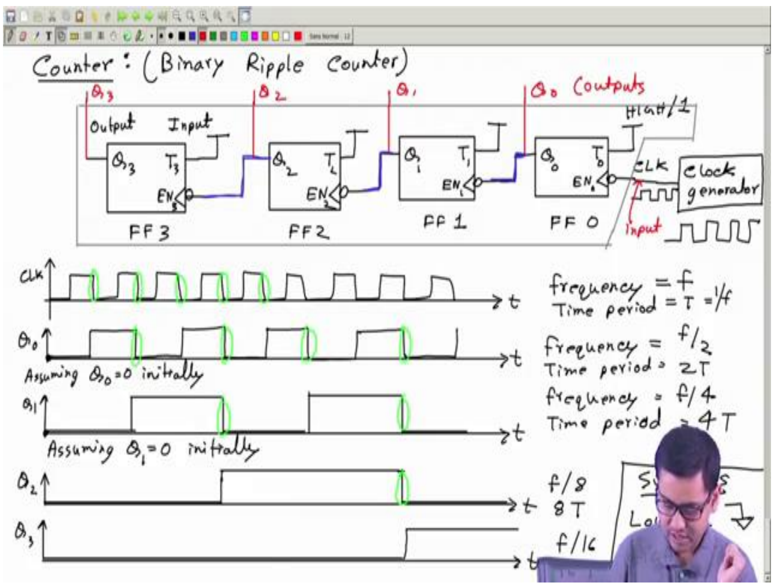

Now, we have studied T flip flop. So, now we will make first more interesting circuit which is of a counter ok. So, we will now study counter. And, this is called a binary ripple counter. So, we will make it using T flip flops ok. So, let us see how. Say, I take a couple of T flip flops, let me take a few 1 2 3 and 4. So, these are all T flip flops and so, they will have input and output.

So, let me draw the input on the right side and the output on the left side ok. I am doing it on purpose, there is a small reason and there is no harm in drawing the input on the right side and output on the left side. Although in general we do it opposite, but here I am doing it on purpose ok.

So, this is Q output, T input. So, it will have another input enable, let me use a edge triggering and negative edge triggering this is enable. So, all these T flip flops are like that only ok. And let us call them let us give some names flip flop 1 2 3 4 or whatever. So, let us call it flip flop let us call 0, flip flop 1, flip flop 2, flip flop 3. I am counting from right to left again there is no harm in doing that you can also count from left to right ok.

So, then you can call this Q 0 T 0 Q 1 T 1 Q 2 T 2 Q 3 T 3 enable 3 enable 2 enable 1 and enable 0. Now, what I will do, I will say take a clock generator ok. So, let us take a clock generator, it can be a crystal oscillator or whatever it is what is a clock generator, it generates a square wave continuously ok. So, this is it is output. So, clock generator generates clock signal continuously with same period or same frequency and what I will do I will connect this output here. So; that means, I have this clock signal square wave coming to this enable continuously.

And then what I will do is this I will connect this T T 0 to voltage level 1 ok. So, this is the symbol for logic 1. So, let me write it here symbol. So, you know that this symbol means ground or earth or 0 potential. So, often we also draw it like this. So, this is and in case of digital circuits, this is like low, this represents logical low. Similarly, logic high can be represented with this symbol with a bar like this so, this is the symbol for logic high ok.

So, this is connected to logic high or 1. So, this is 1 continuously right. So, this is continuously 1. Similarly, this also I will connect to logic 1, this also to logic 1; these are all connected to logic 1 permanently. So, these toggles are on always. Now, what happens this clock pulse is coming. So, let us call this signal as CL K clock ok. So, now, let us draw some timing diagram, this is time versus clock CLK ok. And, this is like this 0 1 if this is like this it may be a few new from frequency, but my drawing is not ok.

Then, how will this Q_0 output change let us find data out. So, Q_0 how will 0 behave time versus Q_0, this is the output of flip flop 0. So, say initially assume initially $Q_0 = 0$ ok. So, say at this point this is 0. So, assuming $Q_0 = 0$ initially. So, at this point this is 0 ok, then it will change, when will it change, it will change at the next negative edge right. So, where is the next negative edge? So, the next negative edge is here.

So, then this Q_0 will change from 0 to 1 here ok, because this T is always 1; that means, whenever a negative edge comes falling edge comes this will change Q_0 will change. Then where is the next negative edge, next negative edge is here, similarly here, here, here and so on right now; that means, Q_0 will change after this at this point here. So, it will change here will go from 0 1 to 0, then like this ok.

So, now, let me ask you a small question. So, the question is supposing the frequency of this clock signal is frequency is equal to say f, then what is the frequency of Q_0? You see that is half of this frequency f/2 ok. So, because every after I mean every alternative pulses all this negative pulses positive pulses do not work these alternative pulses they change Q_0 right ok. So, every alternative pulse this positive sorry negative pulse they change Q_0. So, if this is changing with a frequency f, then this is changing with a frequency of by 2.

I can also write that the time period if this time period is T, which is 1 by f then here a time period is how much? 2 T right. Now, what I will do next thing is this, I will connect this Q 0 to enable ok. So, this is the important thing to observe ok. So, now, this Q 0 is also this is also a square wave changing at some frequency half of the frequency of this one right. So, instead of connecting a clock I can connect Q 0 here. So, this will also behave like a clock right.

So, then this Q 1 will change, now how will this Q 1 change, Q let us see how will this Q 1 change, Q 1 versus time. Again, assume mean Q 1 = 0 initially ok, because we have to start from somewhere if we do not know the initial value we cannot proceed. So, let us assume it is initially 0 then it will change when will it change, it will change when there is a negative pulse here; that means, at Q 0. So, the negative pulses are here, here, here, here. So, Q 1 will change here from 0 to 1, then here from 1 to 0, then here and so on.

So, now you observe what that the frequency here is f/ half of this, f/4 and time period here is 4 T double ok. So, this is how Q 1 behaves. Now, what I will do next you can guess easily is that I will connect this Q 1 to the enable of flip flop 2. And similarly, I will connect this Q 2 to the enable of flip flop 3. So, then what will happen?

So, this you can do it yourself now. So, let me draw time versus Q 2 again let us assume that it is starts initially with value 0 ok, then it will to change when will it change it will change here and then here. So, then Q 2 is up to this is 0 then here it will become one and then here it will become 0 and so on.

So, the that was Q 2, now Q 3, how will it be time versus Q 3. So, Q 3 will change when there is a falling edge here so; that means, up to this moment from here to here, this will remain 0, then it will go to 1 and will remain at one ok. Once again we are assuming that initial value of Q 3 is equal to 0 I am not writing because I do not have space.

And here the frequency ok, what is the frequency? Frequency is f / 8 time period is 8 T ok. Here for this Q 3 frequency is f by 16 time period is 16 T. So, time period increases from T 2 2 T 4 T 8 T 16 T frequency decreases f 2 half f one-fourth f/ 8, f /16. So, this is how this Q 0 1 2 and 3 will change.

Now, let me do this, let me take this Q 0 1 2 3 as outputs. So, let me take this 1 2 3 and 4 as outputs and let me seal everything here inside a box. So, this everything inside the box is my counter and these are the 4 outputs Q 0, Q 1, Q 2, Q 3 and this so, these are the outputs and this clock here so, this is the input of this box which I call a counter. So, this I will call a ripple counter, it is written here ok. Why do I call it counter that is the thing important thing ok?

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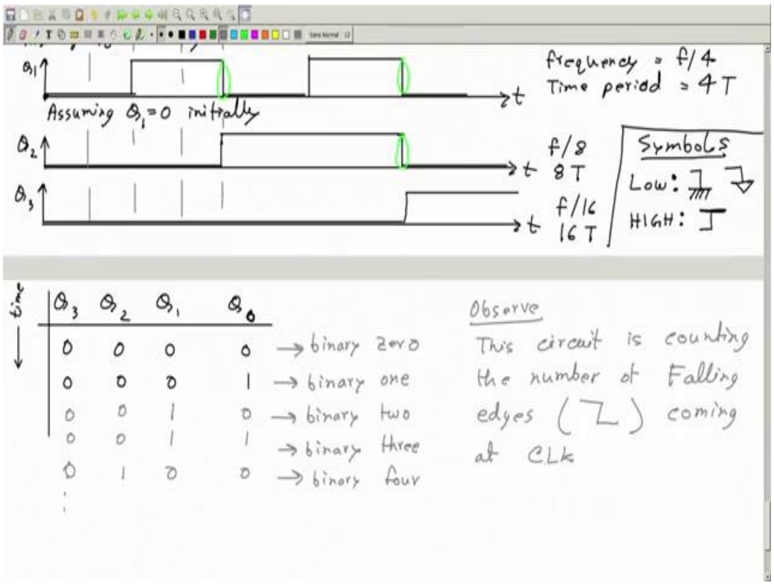

So, for that let us observe let me go to the next page, let me have just this timing diagram in front and let me draw the let me write the value of this Q 3, Q 2, Q 1 and Q 0 as a function of time. So, this way time increases time. So, initially you see all the values are 0 0 0 0 forget clock 0 0 0 0. So, everything is 0 0 0 0.

Now, after that when this first clock pulse comes ok, after this first clock pulse here you see the values are 1 0 0 0. So, at the next moment the values are Q_0 is 1 everything else is 0. Now, what happens after this next clock pulse? So, after this boundary ok, here you see this is 0 1 0 0 0 1 0 0, after that let us see here after this clock pulse so; that means, after this after this line ok.

After, this we have this is equal to 1 1 0 0, 1 1 0 0. And this is how the Q 0 1 2 and 3 is changing with time, after each clock pulse ok. So, now you see this is this number 0 0 0 0 is same as binary 0, this number 0 0 0 1 this is same as binary 1 ok. This is 0 0 1 0 is same as binary 2, this number 0 0 1 1 is same as binary 3. So, these 4 voltages or this Q 0 1 2 3 they are counting the binary number 0 1 2 3 and so on ok.

If you follow this pattern over time, say if let us take another instant so, after this clock ok. So, after this clock the value is say 0 0 1 0, 0 0 1 0, 0 0 1 0 this is nothing, but binary 4. So, this way this counting is going on so; that means, this circuit is counting the number of clock pulses coming here, because every time a negative clock pulse or a falling edge comes here, the binary value or binary equivalent of these 4 numbers Q 0 Q 1 Q 2 Q 3 is incremented by 1 ok. So, every time edge comes falling edge comes here, these 4 numbers, these 4 bits you can call them bits they increase by a value of 1.

So, this here you observe this circuit is counting the number of falling edges ok, falling edges means like this coming at the coming at this point input, call this clock coming at clock CLK ok. So, this circuit is counting the number of pulses that come here. So, that is why we call it a counter right, or why do we call it binary counter why binary, because this 4 bits are counting in the form of binary. So, this 4 Q 0 Q 1 2 3 they represent the value 0 1 2 3 etcetera in binary form. So, we call it binary counter and why do we call it a ripple counter.

This is possibly because all this I mean I do not know exactly why, but I guess because this Q 0 Q 1 Q 2 Q 3 they are all oscillating ok, they are going up and down up and down like a ripple or you can also think that this input also have ripples, they are going up and down up and down, and it is counting the number of ripples or number of oscillations. So, that is why it is called binary ripple counter. And here this we will call the LSB; Least Significant Bit right and this is you know is the MSB; Most Significant Bit of this counter ok. Now, some small questions, which you should answer right now question.

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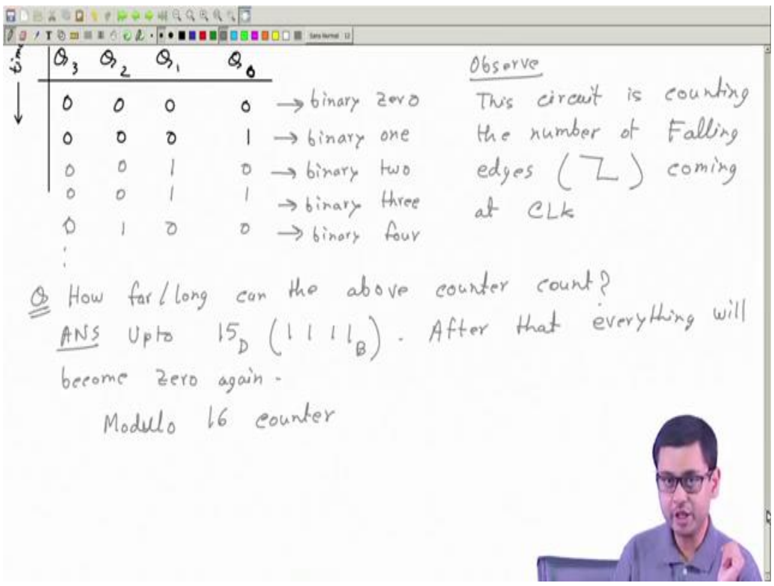

So, the above counter how long can it count or how far can it count, how far or long can the above counter count? Do have the answer the answer is up to 15 decimal 15 or binary so, which is so, this is in decimal or in binary this means 1 1 1 1 in binary ok. So, after this what will happen? After, that everything will become zero again so, this is called a Modulo 16 counter. Why 16 because it counts 16 numbers starting from 0 to 15 ok. So, there are 16 numbers including 0. So, 0 to 15 there are 16 numbers. So, we call it a Modulo 16 counter ok.

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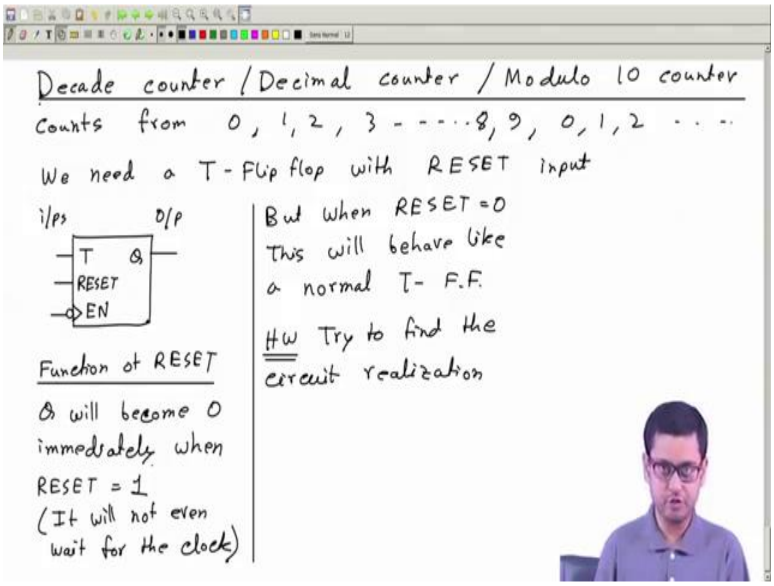

So, now, let us see another important circuit, which will be very useful is a decimal counter or a decade counter, we also call decade counter, you can also call this decimal counter, decade counter is the actual name, but I mean for your understanding, you can call it decimal counter you can also and earn you we this is also same as Modulo 10 counter. So, what is this? So, this will count. So, it will count from so, this will count counts from 0 then 1, 2, 3 so, on up to 9, 8, 9 and after that it will become again 0, 1, 2. So, on this is how this will work ok.

So, how can we make that let us see? So, we will just use the previous ripple binary ripple counter and we will use this idea, but make some modifications to make this decade counter, decade means 10 decimal also means 10. So, and we can make it in different ways, I will show you a way which I think is easy that is why I will show you that, but for that we will need this we need a T-flip flop with reset input ok.

So, what is this? So, this is a T flip flop. So, a T flip flop as you already know has input T it has a clock enable I am taking a negative edge triggered T flip flop this is the output. So, this is the normal T flip flop, but now what we are going to use a modified 1 which will have another input call it reset. So, it has 3 inputs 1 output.

This is a new one, what is the function of reset? Q will become 0 ok, immediately when reset is equal to 1, but when otherwise when, but when reset is equal to 0 this will behave like an ordinary T flip flop, this will behave like a normal T flip flop ok; that means, if this is 0, then Q will change if T = 1 at the moment when a negative edge comes here at enable ok. But this reset is a new input which will make the output equal to 0, no matter what the previous value was if it was 0, then also it will become 0 and if it is 1 then also it will become 0.

So, no matter what the previous value is output will become immediately 0; immediately means so, it will not even wait for the clock. So, it will not even wait for the clock. So, this is what we want this is the behavior of this flip flop that is what we want ok. Now, how to make it, how what should be the internal circuit, I can I keep it that as a small exercise you try it yourself, that will be fun ok. So, homework try to find the circuit, which will realize this behavior circuit realization ok.

Try this it will be a fun, but this is what we want; we want this T flip flop to behave in this way. Now, if we have this T flip flop, then what we will do is this, we will use this structure same structure copy paste ok.

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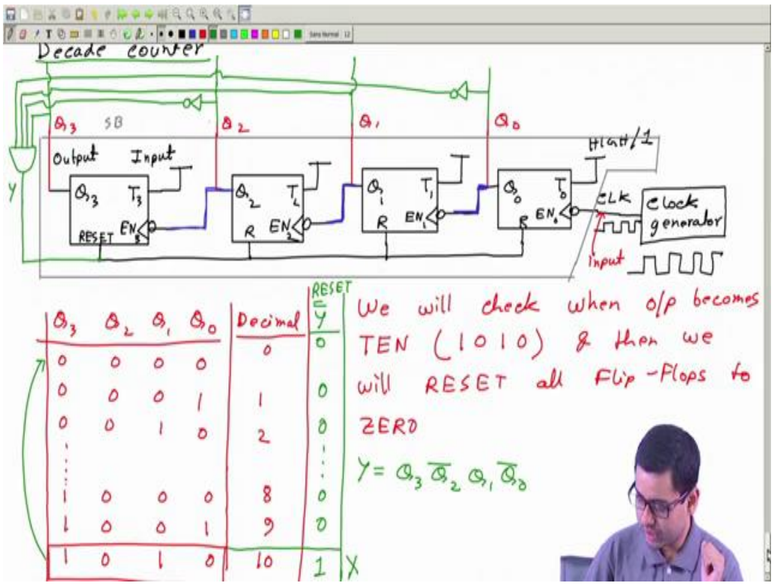

So, now, we are going to make a decade counter. So, what we will do we will use T flip flops, which has the reset function also ok. So, it has it will have another input, where do I write. Let me it is this and let me write the reset here ok, because I do not have space here. So, let me write reset here. So, this is the reset input. Similarly, this is the reset input, this is the reset input so, this is input right, this is not out.

So, I have no space to draw here. So, I am drawing it here, so, this is R ok. So, I have 4 reset inputs and what I will do, I will connect this all reset inputs together, I will sort them and now what I will do is this. So, I know this is Q 0. So, I know this Q 3, Q 2, Q 1, Q 0, they vary with the input pulses like this, starting from 0 0 0 0 ok, then 0 0 0 1, this is how a normal binary counter behaves then 0 0 1 0 so on. So, this is like decimal 0 1 2 and then after a while this will become 8; 8 means so, 0 1 so, 8 is this ok.

So, this is 8 after that it will become 9. So, 9 is 1 0 0 1, after that it will become 1 0 1 0 this is equal to 10 and it will go on, it will count 11 12 15 16 normally, but what I will do now I will check this condition that, the this output is equal to 10 or not ok. So, output equal to 10 means $Q_3 = 1$, $Q_2 = 0$, $Q_1 = 1$ and $Q_0 = 0$. So, this is this point ok.

So, we will do this we will check when output becomes 10, which means 1 0 1 0 right 1 0 1 0 and then we will reset all flip flops; all flip flops to zero how. So, let me do it like this ok. So, this is Q ok. So, I will have a logic circuit logical circuit which is like so, Q 3 equal to 1 Q 3 should be 1 Q 0 should be 0. So, let me put a inverter and then I take this out then this would be Q 1 is 1 so ok. And, let me take a 4 input and gate connect all this, you can take 2 input and gates also and 2 signals at a time, then other 2 at a time and then the result of them together that is also fine.

So, but because I do not have space so, I am taking a 4 input and gate. So, this function is therefore, if you call this call it y ok, then this y is same as what it is same as Q 3 Q 2 bar Q 1, Q 0 bar, this is y. And now what we will do we will connect this y to this reset, these are the outputs ok.

So, these are the outputs and from which I take this take them, combine them and connect to reset. So, what happens the moment ok? So, the moment these 4 values go to these 1 0 1 0 levels the moment, that happens then this y will become 1. So, at this if I write also y. So, y will become y is 0 here, 0 here, 0 here, everywhere it is 0.

But at this moment y is 1. Now, y is connected to reset. So, this is same as reset. So, at this moment immediately reset will be activated and all these values will become 0. So, they will go directly from here to here. So, they will take almost no time from I mean to go from here to here. So, the moment it comes from 9 to 10 immediately it goes to 0 ok. So, as these clocks are coming here 1 by 1, after first clock the number goes from 0 to 1, then 1 to 2 2 to 3 so on then 7 to 8, 8 to 9, 9 to 10 and immediately to 0 ok.

So, then this step does not exist, it does not I mean it exists for a very very negligible amount of time and it does not also count to this clock pulses, because the clock pulse which cause the counter to go from 9 to 10 at that same clock pulse only it has gone from 10 to 0. So, no extra clock pulse is required to go from 10 to 0 ok. So, that is why this arrangement will now circulate between the states 0 to 9, 10 is a almost non existing state ok. So, this circulates from 0 to 9 and so on, 0 1 2 3 4 5 6 7 8 9 and 0 so on. So, this is a decade counter ok.

So, we have realized a decade counter. So, we will talk about another topic now, which is which is also be useful for making digital instruments.

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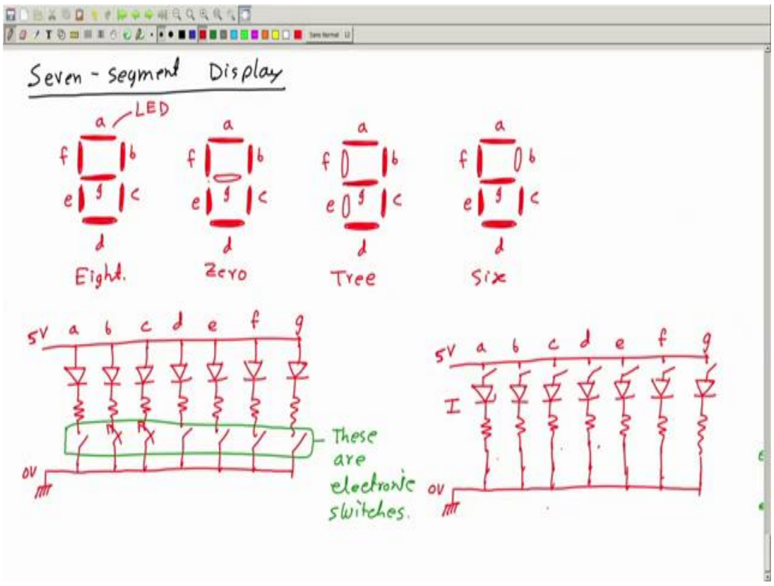

So, this is the display, this is the display unit we call it a seven-segment display, you all have possibly seen it. So, this is basically a set of 7 LED or LCD or 7 lights arranged in this way ok. So, this is one light, this is another light ok, this is another light, this is another light, another, another, another. How many do we have 1 2 3 4 5 6 7 ok. So, this looks like a 8 number 8 right. So, this is called a seven-segment display. Now, this can be led lights and let me just give them some names a b c d e f g ok. So, these are some lights. Now, we can turn on and off these lights to generate or display a different number starting from 1 to 9, 0 to 9 how.

So, if I just say for example, if I turn this light off then ok, this is this look like 0. Now, similarly if I say turn this to off so, this two are off now it looks like three. If, similarly say I can turn say this one off and then it will look like six ok. So, by turning on and off these lights this is 8.

I can generate or display any number from 0 to 9 and now these are say these are LEDs ok, these are these are all LEDs light emitting diode. So, how can we? So, let me draw a circuit diagram of these diodes. So, I have said these 7 diodes. So, let me draw these 7 diodes, 1 2 3 4 5 6 7 ok, say these are so, all this upper side is the positive side, say I connect them all together ok.

So, this is the anode side this is called common anode connection common means all anodes are connected together, all the positive sides are connected together. And, say I connect this to 5 volt some voltage ok. And on the other side I connect some resistances, some suitable resistance and I have a switch and after this switch this side. So, which are the which is this anode side negative side, they are all connected to 0 volt ok.

So, now, what happens, if I say connect this switch, then this led will glow, if I connect this switch then this led will glow. Similarly, by connecting the switches I can choose which LEDs to glow and which to not. So, call this as a b c d e f g; a b c d e f g. So, if I and these are these are all. So, these are electronic switches, they can be transistor ok.

So, they are not manually operated switches they are transistors or some electronically operated switches, although I am drawing them like this symbolically ok. So, by choosing which diodes to turn on say, if I choose for an example if I connect say b and c ok, suppose if I connect b and c like this ok. All others are off only b and c are on then only this two will glow this two will glow and this will be equivalent to binary 1 sorry decimal 1, this display 1 ok.

So, this way we can generate any decimal number 0 to 9 ok. We can we could also have a small variation like this, where instead of having the switches on this side, we could also have switches on the other side ok. So, let me just join them and put switches on this side here. So, this is called now common cathode connection ok. So, this is also possible. And if you are to calculate this resistances, basically then you need to know that how much current should pass through these diodes.

So, that they are properly bright they are glowing properly, then you can divide this applied voltage with these with the required current to compute this required resistances ok. So, if you are asked to design a circuit and compute these resistances, required resistances, where you know that the current that should flow which is which say is I ampere or it is not ampere it maybe milliampere or less ok. And then if you know this voltage is 5 volt then divide 5 volt by I to get what should be the resistance that should that is to be connected in this circuit ok.

So, this is 7 segment display. Now so, we have seen two things, we have seen decimal decade counter which is here, this is a decade counter ok, we have seen how it works. Now, let us let me draw the decade counter in a simplified way like this. So, it is a it will have 4 outputs definitely Q 0 Q 0 1 2 and 3 and these are the 4 outputs.

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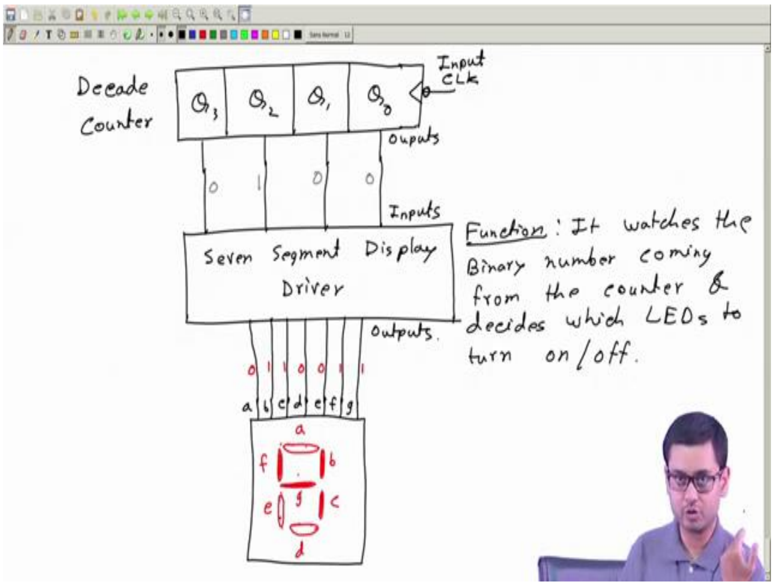

So, let me draw this 4 outputs or flip flops just like this for simplicity Q 0 Q 1 Q 2 Q 3 so, these are the 4 outputs. So, this is a decade counter or decimal counter and it has a input, what is that input? It is this clock pulses ok.

So, I should draw the input. So, let me draw the input here. So, this is the input or you can call it the clock, I should put a triangle to denote the fact that this counter is sensitive to edges so; that means, the counter counts or changes it is value only when a edge comes and I can also draw a bubble to if it is a negative edge triggered counter like this, this was a negative edge triggered counter, but by making by putting a say a not gate here I can also make it positive edge trigger. So, depending on which type of counter I use, I put a bubble or not.

So, this is the symbol of a decayed counter that I will use, then after this we have seen this 7 segment display ok. So, and it will have so, let me put this in a box, it will have 7 inputs 1 2 3 4 5 6 7, a b c d e f g, what are these inputs? These inputs are these states of these switches ok. So, depending on what voltage this display this box receives a b c d e f g these switches here will be either on or off that is what I mean we in this diagram. So, it has 7 inputs and accordingly the display will take a form 1 2 3 4 5 6 7 8 9.

Now, we will put a box which we will call a seven segment display driver ok. So, it has 4 inputs which will connect to this output of the decayed counter. So, these are the outputs of this decayed counter and these are the inputs of this seven segment display, display driver and it will have 7 outputs and this outputs will connect to this 7 th inputs of the seven segment display led display.

So, these are outputs. What is the function of this driver? The function of this driver is to see or watch these 4 values, understand what is the decimal equivalent of this 4 values, say if this these 4 values are like for example, 0 1 0 0. So, this is like a binary 4 right so; that means, the counter is at state or count value 4. So, the function of this driver is to set these 7 outputs in such a way that so, that these LEDs so, the number 4. So, when is that possible? So, to set the number 4, I have to say turn this one on, this one on ok.

So, let me draw it this way. So, to make it 4 I have to make it like this so; that means, f b g and c, f b g and c will be on. So, f this will be 1, b this will be 1, g will be 1 and c will be 1 remaining thing a e d will be 0 a d e is all 0. So, the function of these 7 6 segment displays is to create these outputs. So, that this number is displayed here. So, if I write that it watches or sees the binary number coming from the counter and decides which LEDs to turn on or off this is it is function.

So, how it how will it work this is nothing, but a logical circuit this is just a digital logical circuit made up of AND or NOR gates so on nothing else ok. So, how can we design it? So, we can design it like this. So, we have to make a truth table, then do some binary function simplification using Boolean algebra or Karnaughs map, which ever you are families with whichever you are comfortable with ok. So, let me just tell you that very briefly ok.

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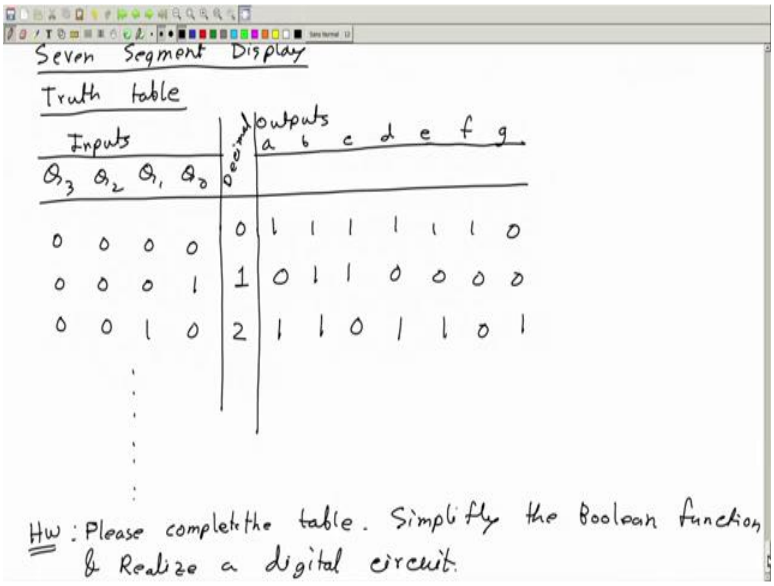

So, for the 7 segment display so, let me write the truth table so, it has 4 inputs Q 3 Q 2 Q 1 Q 0 7 outputs a b c d e f g ok. So, now, if these are like, 0 0 0 0 this is same as a decimal 0. Then, if so, we know to this to show 0 we have to make a b c d e and f on g off. So, 1 1 1 1 1 1 0 g will be off everything else on.

Now, then if this is 0 0 0 1 so, this is like binary decimal 1, then we should make b and c 1 1 1 everything else 0 0 0 0 0. Let us take another value then 0 0 1 0 this is like 2 to display 2 I need a b g e d a b a b g e d ok. So, let me put a b g e d 1 everything else, which is c and f equal to 0 and this way you can fill up the table ok.

So, I just put it as a small homework please complete the table, complete the table and then simplify the Boolean functions, using Karnaughs map or whatever method you like and then realize a digital circuit with AND or NOT gate and realize a digital circuit ok. So, since this course is not really on digital electronics. So, we are not going into further detail you can do this yourself I believe you all can do it this is very simple ok.

So, this is about seven segment display ok, that is it so, this is the end of the first chapter which was on the background required from digital electronics and next day we will start with analog electronics op amps ok.

Thank you.