Electrical Measurement And Electronic Instruments
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Lecture – 78
Astable and monostable oscillator circuits

Hello and welcome. So, we are studying Function Generators and Oscillator Circuits; so, for we have seen two such circuits 5 5 5 timer and another one which is made up of a Schmitt trigger and integrator.

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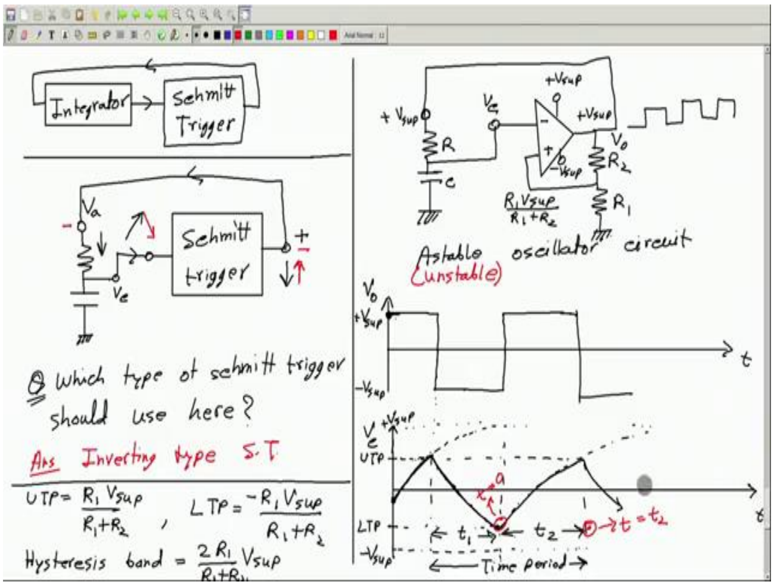

So, recall this, so in one of our circuits we had a Schmitt trigger and integrator and we connected them in a loop. The output of the Schmitt trigger goes to the integrator; therefore, the output of the integrator changes continuously, it increases or decreases and at some point, it triggers this Schmitt trigger to change its output. And this way this entire system oscillates between two stages, two states.

Another circuit let see, I mean which is a simplified version of this; where we can replace this integrator with just a RC circuit, capacitor resistance circuit like this. So, just see that, this actually is also a kind of integrator circuit, kind of integrator; why because if you, say if you ground this and if you apply a voltage here say this is Va what Va. If this voltage is Va; then this voltage call this vc which is the voltage across the capacitor will also increase slowly ok. Why because? If you apply a voltage suddenly, I mean like this. So, this is a battery you, you connect this, switch suddenly, before that there was no charge across the capacitor. So, the voltage V c was 0.

Now, the moment you connect the switch, this potential as is at a voltage V a. So, therefore, current will start to flow through this resistance and therefore, this value of v c will increase slowly with time and finally, it will reach the value of this V a. V a is the battery voltage ok. So, this is also like a integrator circuit, precisely not integrator, it is not this had it be in a strict integrator; then for this constant input voltage the output should grow linearly and indefinitely like this.

But this we will go exponentially and we will saturate; but still this has the property that if you give an input here at this point, and if you consider this as the output, the capacitor voltage, it increases. If we apply a positive voltage, this voltage increases; if we apply a negative voltage, this voltage decreases this is kind of integrator, not precisely integrator.

Now, what we will do? We will take this circuit in place of this integrator and we will use a Schmitt trigger ok. So, now, the Schmitt trigger will have a input and a output; what we shall said do, just like what we did in this circuit we will connect the output of this Schmitt trigger to the input of this circuit ok. And therefore, if this voltage is at any moment positive, then this voltage will increase slowly; and what we will do, we will connect this to the input of this Schmitt trigger.

So, that if this is positive, this will increase continuously and at some point this will reach some threshold, may be the upper trigger point and it will force this Schmitt trigger to change it is output from positive to negative ok. And, then it will be negative and if this is negative, then the negative voltage comes here, so this voltage will gradually drop come down. And at some point it will be low enough to force this Schmitt trigger or trigger this Schmitt trigger to change the output once again from negative to positive. So, this way it will oscillate forever.

And now, let me ask you a question; which type of Schmitt trigger is it? Is it a, it should be a inverting type Schmitt trigger or non-inverting type Schmitt trigger. Which type of Schmitt trigger should we use? Here means in this circuit, can you answer? Just observe that what do you want we want; if this voltage is positive, then we know this is positive, then this voltage will go up with time. And then this increased voltage should cause the output of the Schmitt trigger to go down ok. And, similarly if this voltage is negative, then this is negative, so this voltage is now coming down; and this going down voltage should cause the output of the Schmitt trigger to go up. So, what do you want is inverting type Schmitt trigger, because when input increases output should go down and vice versa.

So, the answer is we need inverting type Schmitt trigger, this is what we need ok. And so, let us draw the circuit of this inverting Schmitt trigger and make the circuit complete. So, to draw the inverting type Schmitt trigger I always start from a non-inverting amplifier ok. So, this is a non-inverting amplifier and now I will change the plus minus sign, positive feedback and input at the minus terminal.

Let us verify that this is a non-inverting sorry, this is a inverting Schmitt trigger. Say if I, say if at any movement this voltage is positive, the output is positive plus v supply ok. So, let me this is plus v supply and minus v supply; if this is plus v supply at any moment and if I want to make it minus, what do I have to do? So, I have the input here to make it minus, to make the input minus, I have to make this voltage higher than this voltage. So, I have to increase this voltage higher than this voltage. So, input is to be increased, if I want the output to go to minus ok. So, this is a inverting type Schmitt trigger, fine.

And just before this we will connect this RC circuit, which is which acts like a kind of integrator C R, you connect this here; no sorry, this comes from the output to the input and this output goes there ok. So, this is oscillator circuit ok, this is a Astable oscillator circuit. Why oscillator? Because you know this output will change from negative and to positive and positive negative forever.

Now, can we draw the voltage waveforms at different points, say here call this V c capacitor voltage and call this V o output voltage let us try. So, time versus, I shall draw V c and V o; say let this v output, let this be the V c time. To start our analysis as always, I shall start with some assumption that initially the output voltage is positive; say this is the, this is equal to V supply plus V supply, this is minus v supply.

So, initially the voltage is positive here. And we shall take some value of initial voltage V c; let us let this be, it can be anything 0, positive, negative. Let us say it is here ok, this is the guest initial value; then what will happen? This voltage comes here. And therefore, the capacitor will charge exponentially like this and it will try to go to what, to which value; this will try to go to this, the height should be plus V supply ok. So, this will try to go to plus V supply, which is the voltage applied here ok.

But will it reach there, maybe not. And in fact not; because let me mark two voltages, two important voltages here, which are the upper trigger point and the lower trigger point of this Schmitt trigger ok. And let me call this R 2 and R 1. So, we can calculate what is upper trigger point and what is lower trigger point. So, what will happen, the moment it reaches this upper trigger point here; it will not increase any further, it will come here and at that moment the output will change from positive to negative. So, here it goes to minus V supply.

And now this minus v supply comes here. So, this is - V supply, this is also minus; and therefore, this capacitor voltage will start to drop. And where will it try to go? It will try to go to minus V supply, let this be minus v supply; then it will try to go to that value exponentially like this. But it will not be able to reach that point, because before that at this point when this voltage reaches the lower trigger point of this Schmitt trigger, the output of this Schmitt trigger will change again from negative to positive.

So, here the output will become positive, ok. So, this way this process will continue. Now it will again try to go to this value, plus V supply, but the moment it reaches this upper trigger point, here the output will change again and this will continue right. Now, so we know how it will work ok. Now let us ask some small questions ok. So, for example, what is the value of this UTP and LTP or; that means, what is the range between which this capacitor voltage oscillates ok.

So, let us find it out. So, let us find out UTP, we did it before. So, we will do very quickly, I will not write a lot of details. So, to find UTP, we will assume that, initially say this voltage is positive. So, this is also, so this voltage is positive; then we will ask what value of V c will make it negative. So, this value is positive assumed and we will ask what value V c will make the output negative, right. So, what is that value? So, this is positive; if this is positive means plus V supply.

UTP = $\frac{R1\, Vsup}{(R1+R2)}$

LTP = - $\frac{R1\, Vsup}{(R1+R2)}$

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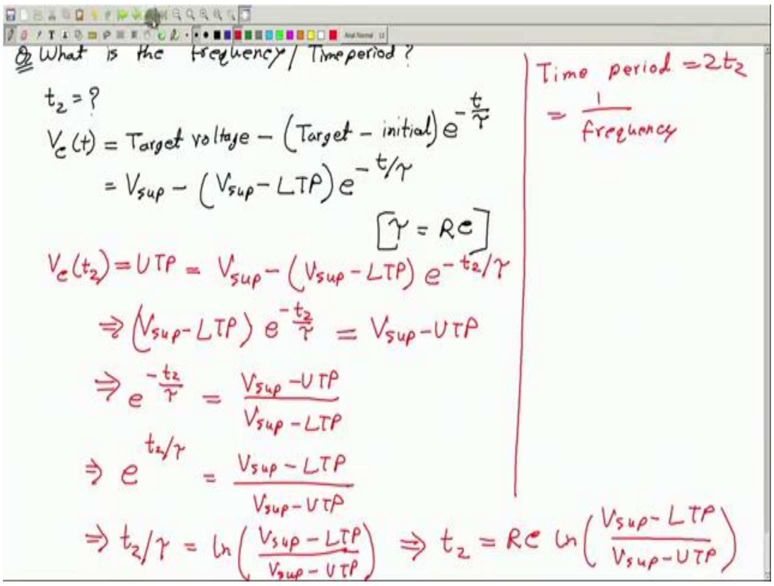

So, what is the frequency or time period ok? So, the time period is here to here. So, this is time period and also you will see that these two halves are symmetric ok. So, this and this are symmetry. So, therefore, these two times are same. So, if I call this time as t1, then time period is 2 t1. So, let us find the value of t1, you can also find this value. And so, if we add them, you get the total time period ok.

So, let us call this t2 ok. So, that is find ok, let us find any of them t1 or 2; say we find the value of t2. How do we do that? So, here you see the capacitor is being charged from a value of LTP and it is reaching the value of UTP. So,

Vc(t) = target voltage – (target-initial) $e^{(-t/\tau)}$

= Vsup-(Vsup-LTP) $e^{(-t/\tau)}$

Vc(t2) = UTP = Vsup-(Vsup-LTP) $e^{(-t2/\tau)}$

$e^{(-t2/\tau)} = \frac{Vsup-UTP}{Vsup-LTP}$

$\frac{t2}{\tau} = \ln\left(\frac{Vsup-LTP}{Vsup-UTP}\right)$

$t2 = RC\ \ln\left(\frac{Vsup-LTP}{Vsup-UTP}\right)$

So, you can put this value here, which I am not doing and you can also put the value of LTP and UTP in this expression using this ok. So, you can now put the values and complete this, I believe ok. So, that is about this particular circuit, we shall now go to another circuit. Before that, let me just tell you that, I already have said that this is called an Astable oscillator circuit. What is meant by Astable? Astable means unstable ok. This is something which cannot, I mean which is not happy in either high out with high output or with low output

When the output is high, after a while it makes the output low; but even then it is not happy, after a while it makes the output high ok. This is like a circuit which cannot decide and get to a fixed value ok. So, it keeps oscillating, it unstable, it cannot make up it is mind where which value it should take, something like that it is a mad man ok.

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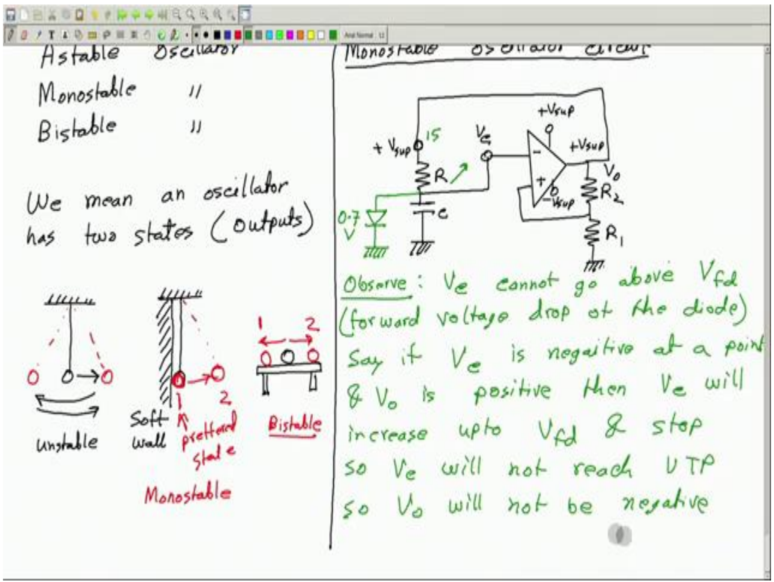


So, we shall talk about two more things, which you have possibly hard is. So, Astable we already have said, there is something called Monostable oscillator and there is also something called Bistable oscillator. So, here in, I mean in this context we mean that. So, we mean I mean in this context that, an oscillator has two states or may be two outputs like high and low ok, plus and minus something like that. And Astable or unstable oscillator is like a mad man, who cannot decide which state it is he or she should be in. So, he or she keeps oscillating between two states continuously.

A Monostable oscillator is one which likes one of the, one among the two states. So, let me just give you some small example maybe, say if I just have a pendulum and which I mean, where there is no friction no loss. So, if you bring it to the right side, it will come back and go to the left side; but when it goes to the left side, it again comes back to the right side and it keeps on oscillating forever. So, this is unstable, Astable.

Now, let us think of another pendulum, where say we have a wall, a soft wall or a cushion and the pendulum is hanging from here ok. So, it has two states, the two states I mean, they are defining two states as this is one state. So, this is one position and the other position is say here; you if you bring this here, it will always come back and stay here, it will not bounce because of the softness. So, it has two states 1 and 2, but this likes this state 1; if you bring it to state 2, it will go back to state 1. So, this is the preferred state.

So, this is called Monostable oscillator ok. So, this pendulum is happy in one of the one among the two states; but is not happy in the other state. So, if you bring it to the other state, it will always come back after a while, it will take some time to come back ok. But here there are two states, the left and the right; and the pendulum is not happy in either of the two states ok.

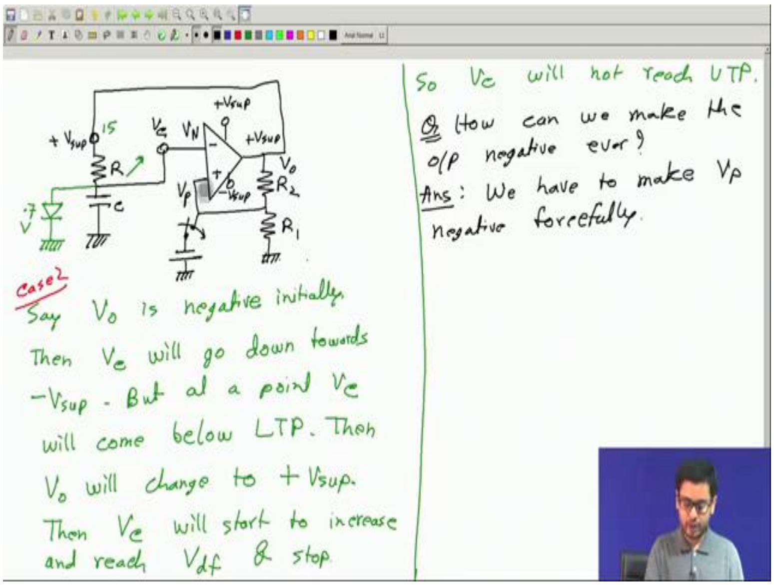
And there is something also called Bistable and this you can thing that there is a table, on which there is a ball rolling and you can keep the ball either on the left side or on the right side of the table and it is a flat table. So, if you bring it to the right side, it will stay there; if you bring it, if you keep it to the left side, it will stay there, it is like a by. So, these are the two states 1 and 2. And we are I mean, note that we are not considering any other intermediate position as a valid state, we are not considering that at all ok.

So, the only two extreme positions left and right we are considering here. Similarly here the extreme left and extreme right we are considering here also. Intermediate states we are not considering. So, here this is Bistable. Now, the circuit that we have seen here, this was unstable or Astable; because it has two outputs, two states low and high, when the output is low after while it goes to high and if it is high after while goes to low. So, it was unstable. Now, let us make a Monostable oscillator circuit. We shall start from this circuit and we will modify it.

What we shall do is this; that we shall put extra diode ok. So, this is new thing we are adding. So, how does it modify the behavior of this circuit, observe that value V c cannot go above the forward voltage drop of this diode ok. So, cannot go above call it V f d, which is the forward voltage drop of the diode. Why will why this voltage will not go beyond that, because this voltage is high always, can be high, this can be plus V supply which is plus 15 volt; but this voltage forward drop is something around 0.7 volt for a silicon diode ok.

But this is say 15 volt. So, we have 15 volts applied here, and say initially the capacitor is not charged, so this voltage is 0. So, these 15 volts will charge this capacitor, current will flow through this R and this capacitor will get charged. So, this voltage will then increase, and the moment it increases to the level same as 0.7 volt; then this diode will be on, and this will act like a short circuit. So, the entire current will flow through the diode and will not go to the capacitor. So, the capacitor voltage will not increase any further ok, the entire current will bypass through the diode ok.

So, the capacitor voltage cannot increase ok. So, therefore, let us see what is the implication of this fact ok, say if V c which is this voltage ok; that is capacitor voltage is a negative at some moment at a point of time, then what will happen? This is negative and let us say this is plus, this is out output is positive and Vo is positive. Then V c will increase, because current is flowing through the R, resistance R up to V f d and stop. So, V c will not reach upper trigger point of the Schmitt trigger. So, V o will not be negative on it is own ok. So, if the output is positive, it is not going to switch back to negative. So, V o will not be negative.(Refer Slide Time: 36:14)



Now, let us see what happens if the output is negative initially. Now say Vo is negative ok. So, somehow the output is negative initially; previously we have seen here, the output was positive. So, this is case 1. So, let me write this is case 1, case 1 where the output is positive; and therefore, Vc will increase, but it will not reach upper trigger point. So, output will remain positive for ever.

And this is case 2, where we start with the assumption that the output Vo is negative somehow anyhow ok, somehow it is negative; then what will happen, then this is negative. So, then the capacitor will charge to negative voltage, then Vc will go down towards minus V supply; but before that, but at a point this voltage Vc will reach or will come below the lower trigger point of the Schmitt trigger ok. So, it will come below the lower trigger point; and then what will happen? The output will change, then V o will change to initially it was negative, so now it will become positive, change to plus V supply ok.

So, then the output goes to plus V supply. And once this is at plus V supply, so then capacitor V, capacitor voltage Vc this will start to increase, Vc will start to increase and reach this voltage, the forward drop of this diode maybe 0.7 volt will reach Vd f and stop ok. So, Vc will not reach upper trigger point ok. So, it will stop there, with the output being positive. So, what have we seen, let me summarize; case 2, if the output is negative; then this will make this voltage more and more negative, and then the lower trigger point will be reached. So, the output will become positive; we started from negative output, but we went to positive output.

But case 2, once this is positive, this will try to increase the capacitor voltage; but will not be able to increase it beyond 0.7 volt. So, we will not reach the upper trigger point here. So, output will remain positive. So, positive output is a stable output, once we are in positive output, we will remain there forever; but if we by chance go to negative output ever that is not stable, the output will become positive very soon.

Now, you should ask that how can the output be negative ever ok; because we saw the positive is a positive output reach stable output. So, how can we make the output negative ever? So, the question is, how can we make the output negative ever ok? And the answer, the only I mean not only, the one answer is that; if you by force make this higher than this, by force, by some chance or which means you have to make this voltage ok, this is called this V p V N. So, if you by force, by somehow if you make V p lower than V N ok; then the output will be negative.

So, for example, what we can do? Say, I mean one possible way is, take a battery and connect it; if you connect it ok, if you connect this, then this voltage, this negative voltage is directly coming here right. So, the output will be directly negative and if the output is directly negative, then this is lower than V N. So, output will be negative. So, the answer is. So, we have to make V p negative forcefully ok, this is called triggering.

And we shall continue about this in our next class ok. Just think about it; that to make the output negative, we can forcefully apply a voltage like this, somehow we have to make this negative.

Thank you.