DC Power Transmission Systems
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Lecture - 28
3 and 4 valve conduction mode of 6 pulse LCC

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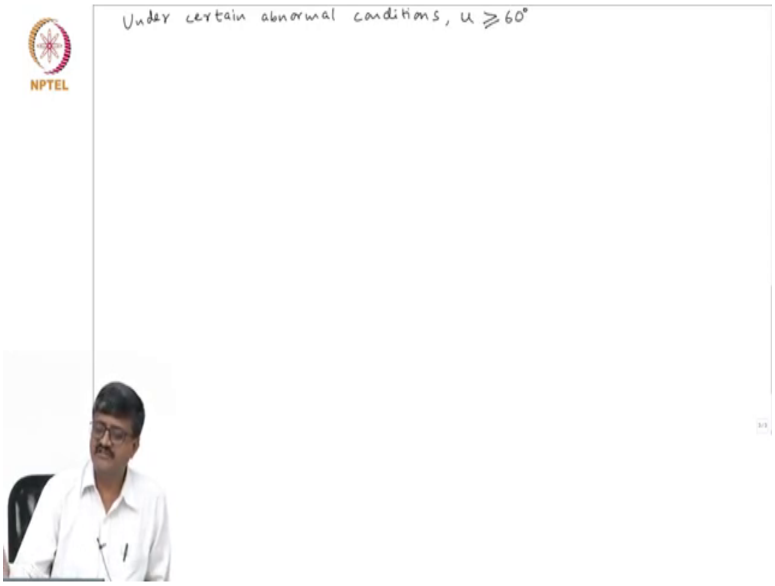

So, under certain abnormal conditions such as a DC line fault or a dip in the AC voltage u can be greater than even 60 degree also consider is abnormal. So, even 60 degree is an abnormal condition.

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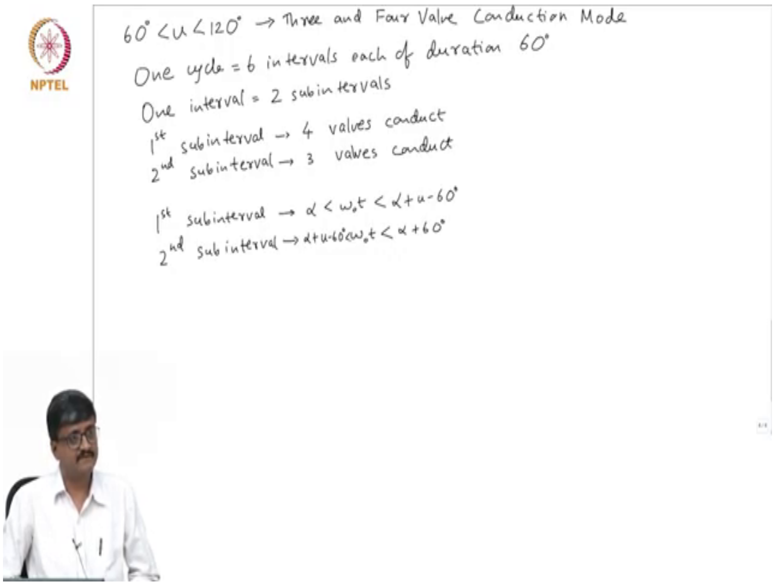

So, let us try to analyze this case where u is greater than 60 degrees and less than 120 degrees. So, what we do is we again try to analyze by considering the factor that each cycle of the AC side wave form can be divided into 6 intervals and each interval can be divided into 2 subintervals.

So one cycle, so, when I say cycle it is this cycle or period of the voltage or current on the AC side. So, one cycle is equal to 6 intervals or each of durations 60 degrees and one interval is equal to 2 subintervals. Now why I am saying 2 subintervals? At any instant either 4 valves conduct or?

Student: (Refer Time: 01:50).

3 valves conduct. Now that is true for any value of u between 60 and 120. So this range of u corresponds to, what is known as 3 and 4 valve conduction mode. So, the previous case of u less than 60 was 2 and 3 valve conduction mode. So, this is 3 and 4 valve conduction mode.

So, the first subinterval is the one, where 4 valves conduct. The second subinterval is a one where 3 valves conduct. See this is somewhat similar to the definition of first and second subinterval in that 2 and 3 valve conduction mode also.

So, in the first subinterval there were 3 valves conducting there and in the second subinterval 2 valves are conducting. Now in 3 and 4 valve conduction we call the 4 valve conduction period as first subinterval ok, the other one is the second subinterval ok. So, suppose the first subinterval I mean that we are going to study, corresponds to the subinterval in which valve 3 starts conducting. So, at what instant valve 3 stands on?

Student: (Refer Time: 03:42).

Alpha, valve 3 is always stand on at alpha. So, we have actually defined e a, e b, e c sets that, valve 3 is always turned on at alpha. Now, this is coming from the definition of?

Student: (Refer Time: 03:58).

e a, e b, e c. Please note that; this is coming for a definition say we gave some phase angles for e a, e b, e c 150 degrees and the 30 degrees, minus 90 based on that we see that valve 3 stand on at alpha. So, the first subinterval corresponds to omega o t between alpha and?

Student: (Refer Time: 04:20).

Alpha?

Student: (Refer Time: 04:21).

And?

Student: (Refer Time: 04:22).

Alpha plus?

Student: (Refer Time: 04:23).

u, see if I take alpha plus u now u is greater than 60.

Student: (Refer Time: 04:27).

You are crossing the duration of 60 degrees. See, one subinterval is less than 1 interval and 1 interval is only 60 degrees.

Student: (Refer Time: 04:37).

Let us fill that later.

Student: (Refer Time: 04:40).

So, if I take the sub 2nd subinterval, in the same 1st interval. So, here omega o t is less than.

Student: Alpha plus 60.

Alpha plus 60, but at what instance 2nd interval stops or first I mean the 2nd interval starts or 1st interval stops.

Student: u minus 60 alpha plus u minus.

Alpha plus u minus 60; alpha plus u minus 60 degrees is less than omega o t less than alpha plus 60 for second subinterval. Is that or not? Is that?

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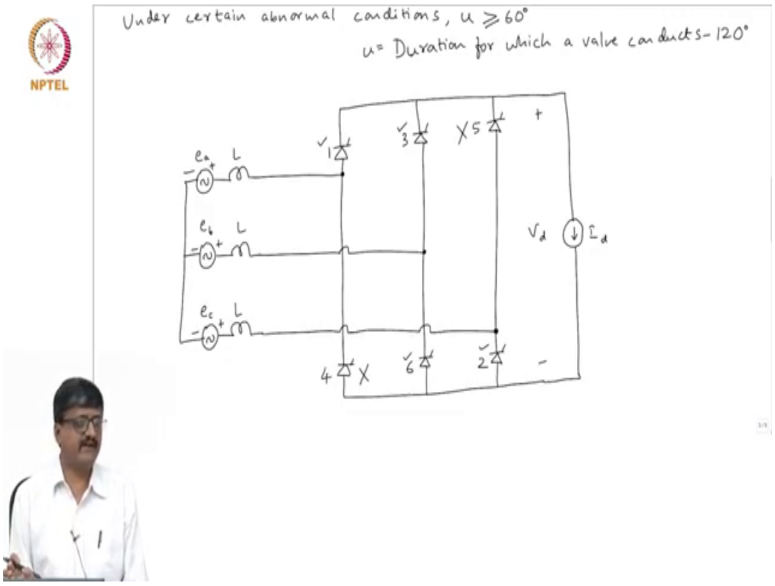

Now, what I will do is I will try to redraw this circuit for one interval at a time it say first interval by just showing those elements which conduct ok, now if I take the first subinterval.

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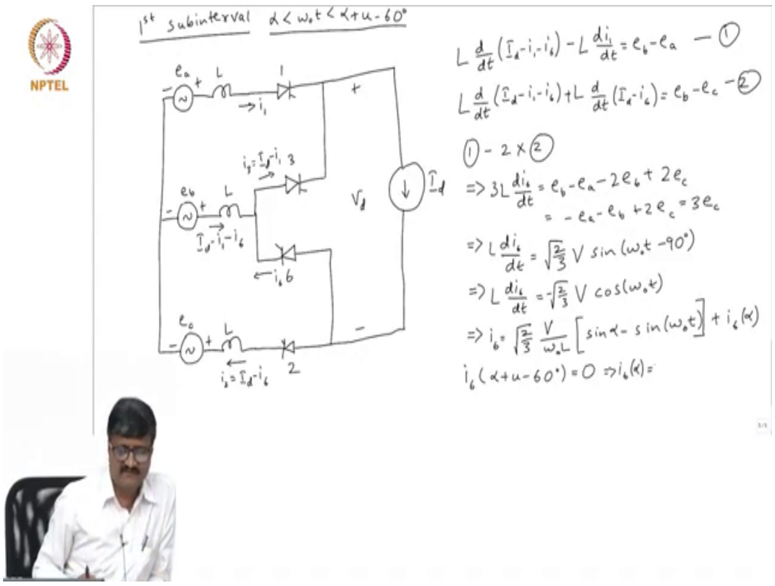

So, let me take the first subinterval. So, in the first subinterval will there be a nonzero current in the three sources e a, e b, e c or if I want to ask first say it is very easy to say that always there is a current on the DC side Id is flowing Id is nonzero. Now which are; which valves conduct in the first subinterval? See look at the definition of first subinterval the first subinterval is from alpha to alpha plus u minus 60 degrees in which 4 valves conduct and alpha is the instant at which valve 3 stand on.

Student: Yes

So, valve 3 stand on and?

Student: 4 valves.

4 valves are conducting means 3 are already conducting. So, which three?

Student: I am saying (Refer Time: 07:02).

So, 3 stand on in the first subinterval.

Student: Yes.

So.

Student: 6 1 2.

So, the other valves which are already conducting are 6 1 2. So, that means, I need not show 5, I need not show 4. So, I will I am just redrawing this circuit without showing the elements that do not conduct that is all ok. What about the 3 voltage sources e a, e b, e c? See when either 1 or 4 is conducting, there will be a current through e a, but 1 is conducting, so there will be a current through e a. If there is a current through 3 or 6 e b will be having some current they are now the both 3 and 6 are conducting so e b is conducting. So, there is a current through e b and since 2 is conducting there will be a current through e c.

Student: e c.

So all the 3 sources and inductances connected in series with the sources are conducting the 3 voltage sources. So, the revised circuit which shows only the elements that conduct current is drawn next. So, I have, I will redraw the same circuit without showing the 2 thyristor valves 4 and 5. So, this is e a, this is e b, this is e c L, L, L. Now there is a current through e a, because 1 is conducting; valve 1 is conducting.

This is valve 1 there is a current through e c because valve 2 is also conducting, and there is a current through e b because valves both valves 3 and 6 are conducting. So, this is valve 3 and this is valve 6. Sorry I should not (Refer Time: 09:45). The anode of 3 is connected to the cathode of 6 now the anode of 3 sorry; the cathode of 3 is actually connected to the cathode; of the cathodes of 1 and 3 are at the same potential ok.

So, this is connected to the cathode the anode of 6 is connected to the anode of 2 because all the anodes of 2 4 and 6 are at the same potential. And the DC side has a current source Id. So, this is the plus positive terminal of the this side it is the negative terminal, Vd is instantaneous voltage. So, suppose I show the current through valve 1 as i 1 and I do not give a separate I mean; this is i 3 and i 3 happen to be equal to Id minus i 1 in the first subinterval. See I am just drawing the circuit for alpha less than omega o t less than alpha plus u minus 60 degrees.

So, for this first subinterval Id sorry i 3 is Id minus i 1 ok, and this is i 6. So, if I take the current through this inductor L, connected in series with e b the voltage source with voltage e b, then it is Id minus i 1, minus i 6 and the current that is flowing through this inductance or valve 2 is i 2 which is nothing but Id minus i 6 so this is the 1st subinterval. Now, let us try to solve for the currents.

So, you see that; there are see I can now use the mesh analysis. So, how many loops are there? So, if I want to solve for the currents. So, given the voltage sources e a, e b, e c and given the current Id. I want to solve for the, remaining quantities. So, mesh analysis is appropriate. So, ah; if I want to apply mesh analysis; that means, apply Kirchhoff's voltage law to the loops. So how many loops are there? There are?

Student: (Refer Time: 12:52).

Student: (Refer Time: 12:53).

Though there are 3 one loop current is known. So, there is one loop consisting of valves 3 6 and the current source Id. So, the current Id is known that is given; there are other 2 loops with current i 1 the other current is i 2 ok. So, I can either solve for i 1 and i 2 or i 1 and i 6 I mean there is a, but only 2 independent quantities have to be determined by application of the Kirchhoff's voltage law to the 2 loops ok.

So, I will just apply Kirchhoff's voltage law to these 2 loops. So, if I take the loop consisting of e b, e a under 2 inductances and of course, the valves 1 and 3. So, if I take this loop consisting of e b, e a valves 1 3 under two inductances L. Which are connected in series with e a and e b. So, if I apply Kirchhoff's voltage law, I get L d by dt of Id minus i 1 minus i 6 minus L d i 1 by dt is equal to eb minus ea. Is that? Similarly I take the second loop consisting of e b e c valves 2 6 under two inductances L connected in series with eb and ec.

So, apply Kirchhoff's voltage law I get L d by dt of Id minus i 1 minus i 6 minus here the current direction is a opposite. So, plus d by L d by dt of Id minus i 6 is equal to e b minus e c ok. So, I am getting two equations here. So, there are two unknown quantities i 1 and i 6. So, I have not written in terms of i 3 and i 2 is not necessary once I know i 1, i 6 I can get i 3 and i 2 because Id is known. So, I will call this as equation 1 and this as equation 2.

So, 2 linear equations; I mean straight forward to solve ok. So, solve for i 1 and i 6 see if I take the first equation; see if I want to solve what i need to do is I say eliminate one of them. Suppose I take 1st equation minus 2 times 2nd equation. What do i get? My intension is to eliminate one of the quantities suppose I want to eliminate i 1. So, first I will solve for i 6.

So, I get 3 L d i 6 by d t equal to e b minus e a. You see that I mean see derivative of Id with respect to time is 0, Id is a constant. So, the purpose of this manipulation is to get rid of i 1 one of the quantities. So, I write I get it the equation in terms i 6. So, it is e b minus e a minus 2 e b plus e c sorry plus 2 e c. So, this you get simplified to minus e a, minus e b plus 2 e c which is nothing but what is the next simplification minus e a minus e b is see e a plus e b plus e c is 0.

Student: (Refer Time: 17:04).

So, it is minus e a minus e b is e c so it is 3 e c. So, I can just cancel that 3 on both sides. So, what i get is L di 6 by dt is equal to e c so which is root 2 by 3 V sin omega o t minus 90 degrees. So, it is easy to do the integration if I right this as di 6 by dt is equal to root 3 by root

2 by 3 V I write this as minus cos omega o t. So, solve this for i 6, Can I say that this is equal to root 2 by 3 V by omega o L into?

Student: (Refer Time: 18:28).

Sin alpha minus.

Student: Sin omega o t.

Sin omega o t.

Student: Into root 2 by 3 by omega l (Refer Time: 18:38).

Into V.

Student: (Refer Time: 18:40).

Root 2 by 3 into V by omega o L.

Student: Into V by omega o L.

Plus.

Student: i 6 of alpha.

Sorry plus i 6 of alpha. That is correct. How to get an expression for i 6 of alpha? Say I cannot leave it like that I have to write it in terms of other known quantities.

Student: Sir we know that.

Student: i 6 will be going to 0.

Student: And.

The end of?

Student: (Refer Time: 19:15).

1st subinterval.

Student: Subinterval.

So; that means, i 6 at alpha plus u minus 60 degrees is equal to?

Student: 0.

0.

Student: So, why do not we put that?

So, if I substitute omega o t equal to alpha plus u minus 60 degree in the previous equation I get left hand side 0. So, that will give me i 6 of alpha. So, this gives the expression for i 6 of alpha ok. So, once you get i 6 of alpha substitute in the previous equation you get expression for i 6 ok.

So, will I will stop here. I will continue from this point in the next class then we will solve for i 1. So, that completes the analysis of 1st subinterval, then we have to go to 2nd subinterval, then we do further manipulations and I get some equations which are similar to the ones that were obtained for the normal operation 2 and 3 valve conduction mode ok.

So, the purpose of studying 3 and 4 valve conduction mode is there can be some abnormal conditions, but one difference is we will not getting to study of harmonics for 3 and 4 valve conduction mode because, when we study harmonics. What is the purpose of studying harmonic content? Why do we need to study (Refer Time: 20:40)? Why we study? I mean if there is harmonic content. We know there is harmonic content. We want to know; what is the amount of harmonic content knowing that what next. What do we do with that? Why do we want to know?

Student: (Refer Time: 20:55) Eliminate.

Eliminate how?

Student: (Refer Time: 20:58).

So, finally, we will use that to design filters. So, when it comes to abnormal operation abnormal operation may be existing for a few seconds or a few minutes in a year. So, for abnormal operation we are not going to minimize harmonics it is an actually not eliminate harmonics minimize harmonics using filters. So, filters are design to minimize or reduce harmonics. So, we are not going to worry about some abnormal conditions which may exist for a few minutes in a year ok.

So, what we are bothered about normal operation. So, harmonic analysis is done only for normal operation because we are going to design filters only for normal operation not for abnormal operation ok, but we need to look at a few other quantities when it comes to abnormal operation. So, only those things we will be doing so; obviously, we will not be doing any Fourier analysis for abnormal operation ok. So, normal operation itself I mean, I mean we have there is it is sufficiently laborious. I do not know if you have tried you would have noticed that.