DC Power Transmission Systems
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Lecture - 31
Analysis of 3 and 4 valve conduction mode of 6 pulse LCC: Part 3

So, in the last class we formed a table for 3 and 4 valve conduction mode. So, we got the expression for v d and voltage across valve 1 for all the twelve subintervals. So, if I want to know the voltage jumps. So, here the purpose of knowing voltage jumps is to ensure that the thyristor valves are rated for the required dv by dt values. So, if I try to look at the. So, I will not again rewrite the table.

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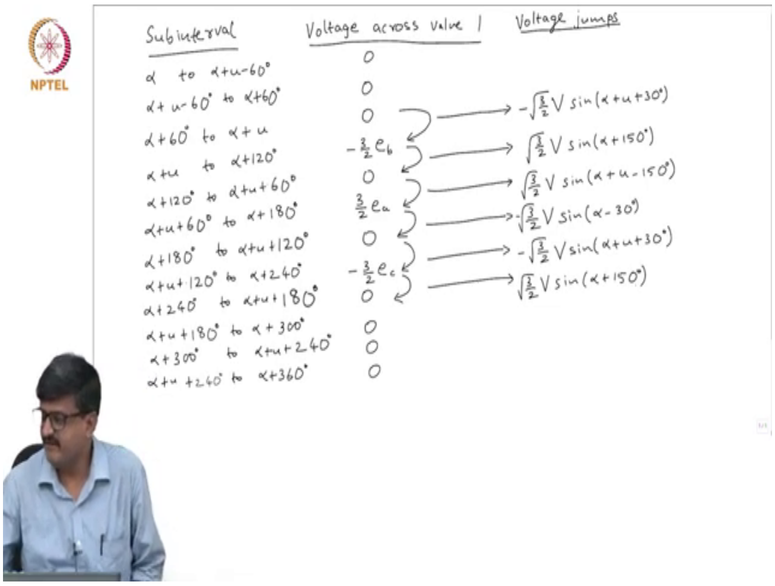

So, I will just say what are the different sub intervals in which, I get the different expressions for voltage across valve 1 and directly write the expression for voltage jump. So, if I take alpha to alpha plus u minus 60. So, there are many sub intervals where the voltage across valve 1 is 0.

So, we have in the first sub interval 0, second sub interval 0, third sub interval 0. Then in the fourth sub interval it is minus 3 by 2 e b. Then, 0 then, 3 by 2 e a; then, 0 then minus 3 by 2 e c, then 0, 0, 0, 0. So, if I want to know, what are the voltage jumps? So, you see that there are how many jumps 1 2 3 4 5 6 jumps. So, from here to here, here to here, here to here, here this one and finally this one. So, the expression for the 6 voltage jumps. So, I will directly write the expression.

So, what you need to do is, take the value of take the expression for voltage across valve 1 and substitute the appropriate value of omega o t. You will get a voltage jump. So, I need to take for example, the first voltage jump is minus 3 by 2 e b evaluated at alpha plus c. Then the second jump is 3 by 2 e b evaluated at alpha plus 120. So, if I try to take this expressions and substitute the appropriate values of omega o t. So, I will get these expressions or voltage jump minus root 3 by 2 V sin alpha plus u plus 30 degrees that is the first voltage jump. So, I will leave it to you to verify this.

The second voltage jump is sorry 3 by 2 V sin alpha plus 150 degrees, then 3 by 2 under root V sin alpha plus u minus 150 degrees. Then root 3 by 2 V sin minus sin minus root 3 by 2 V sin alpha minus 30 degrees; minus root 3 by 2 V sin alpha plus u plus 30 degrees. Then root 3 by 2 V sin alpha plus 150 degrees. Now, we also founded I mean a more detail table with a column for v d as well. So, from the column for v d which gives expressions for v d in the 6 in the 12 sub intervals; we can get the average value of v d. So, if I want to find the average value of v d.

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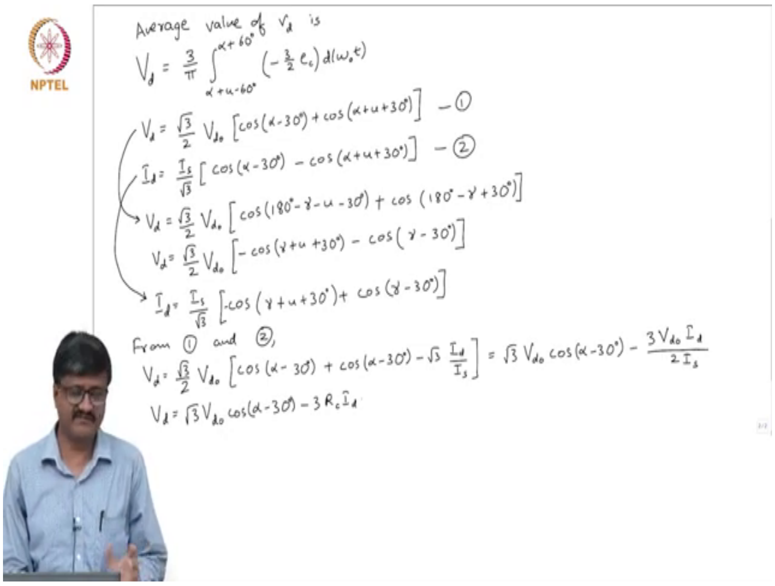

So, it is denoted by upper case V with the subscript d. So, what I can do is, I can I know that V d repeats after every 60 degree. So, I have to just take the expression for V d for the first interval. So, in the first sub first sub interval it is 0. So, I have to just take the expression for V d in the second sub interval. So, it is 3 by pi which is reciprocal of 5 by 3. So, I am just taking for 6 degrees. So, in the second sub interval, which is from alpha plus u minus 60 degrees to alpha plus u sorry alpha plus 60 degrees. The expression for V d is minus 3 by 2 e c d omega o t.

So what you need to do is just substitute the expression for e c and integrate and leave it to you I will again leave it to you to verify that this is equal to root 3 by 2 V d o cos alpha minus 30 degrees plus cos alpha plus u plus 30 degrees. So, this is the expression for V d. Now in the last class; we got the expression for I d in terms of I s alpha and u if we recall we derived this equation sorry just rewrite that equation. I d is I s by say of course, the last step I did not go through all the manipulations I am asking you to do that.

Yeah, by the way I just want to let you know, whatever I have asked you to do so far are all simple ones except the expressions for the fundamental and harmonic component in for the DC side voltage and the AC side current in the case of 2 and 3 valve conduction mode. So, only those are laborious, all others are I mean if something which can be done in just a few minutes ok. So, only if you look at the 2 and 3 valve conduction mode; the fundamental and RMS expression for the AC side current and the RMS value of the harmonic say the sorry, the fundamental and harmonic component RMS of the AC side current. And the RMS value of the harmonic of the DC side voltage these two are a bit laborious all others are straightforward ok.

So, one should be able to do it in just a few minutes. So, this is I s by root 3 cos alpha minus 30 degrees, minus cos alpha plus u plus 30 degrees. So, what we do is, we try to again get this expressions for V d and I d in terms of gamma instead of alpha. We have defined an angle gamma, I also said why we define that gamma. See gamma is actually called extinction angle and it happens to be the competition margin angle for normal inverter operation ok. So, if I want to write this instead of gamma. What is gamma? Gamma is nothing but 180 minus alpha minus c ok. So, if I write the expressions. So, take the expression for V d. V d is root 3 by 2 V d o.

So, if I write alpha in terms of gamma, it is cos 180 degrees minus gamma minus u. See gamma is just a definition; I mean gamma is given by 180 degree minus alpha minus u that is all. Now, why I also said why you defined that. So, there is a purpose for each and every definition; plus alpha plus u is 180 minus gamma plus 30 degrees. So, I can write this as V d is equal to root 3 by 2 V d o minus cos gamma plus u plus 30 degrees minus cos gamma minus 30 degrees. Similarly, I try to write the expression for I d in terms of gamma instead of alpha.

So, if I take I d sorry, I d is I s by root 3 cos. So, can I straight away write the expression? I mean, if you look at the expression for V d. So, you see that there is cos alpha minus 30 in both expressions cos alpha plus u plus 30. So, I can write this as minus cos gamma plus u plus

30 degrees minus cos gamma minus 30 degrees. Yeah ,only difference is this is plus because this there is a minus cos alpha plus u plus 30. Now, if we recall, we related this V d and I d through R c, we defined a commutation resistance R c.

So, we can actually try to relate V d and I d in this case also. See what we are doing is in the case of 3 and 4 valve conduction mode it is an abnormal operation. So, if I take this expression V d. So, what I am trying to do is ok. Let me instead of suppose I take this as equation 1 this as equation 2 ok. So, I use this 1 and 2 to get one more equation that is V d is equal to root 3 by 2 V d o cos alpha minus 30 degrees.

Now what I do is; I replace this cos alpha plus u plus 30 by an expression for that involving I d and I s and alpha from equation 2. So, from equation 2, I get cos alpha plus u plus 30 as cos alpha minus 30 degrees minus root 3 I d by I s. So this can be written as root 3 V d o. So, there is cos alpha minus 30 cos alpha minus 30. I think, I made a mistake here. This is not the root 3, this is root 3 divided by 2 sorry. So, that 2 gets cancelled. The 2 in the denominator gets cancelled. So, we get root 3 V d o cos alpha minus 30 degrees minus root 3 into root 3 is 3 V d o, I d by 2 I s ok.

So, what is V d o by 2 I s by definition of R c? R c is defined as V d o by 2 I s. So, we get V d equal to root 3 V d o cos alpha minus 30 degrees minus 3 times R c I d. Because, V d o by 2 I s is given a notation R c; R c is just a notation for V d o by 2 I s that is all.

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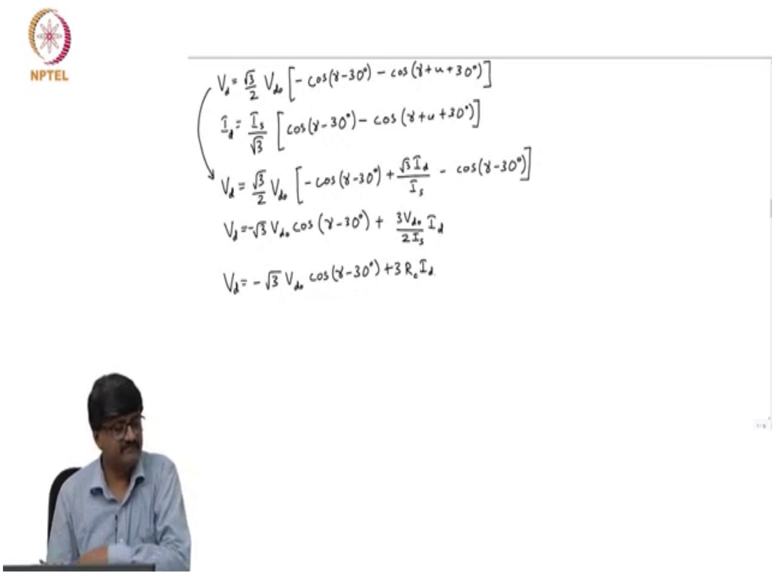

So, we have this two equations, the first question relates V d V d o gamma and u. The second question relates I d I s gamma and u. Now I can write the first equation that is this equation as V d is equal to root 3 by 2 V d o into minus cos gamma minus 30 degrees. Now the second term on the right hand side has minus cos gamma plus u plus 30 degrees. So, I use the next equation to eliminate cos gamma plus u plus 30 degrees. So, if I do that I get plus root 3 I d by I s minus cos gamma minus 30 degrees.

So, if I simplify this, I get root 3 V d o cos gamma minus 30 degrees with a negative sign. So, minus root 3 V d o cos gamma minus 30 degrees plus 3 V d o by 2 I s I d. So, I can write this as V d is equal to minus root 3 V d o cos gamma minus 30 degrees plus 3 times. We have defined a quantity R c which is V d o by 2 I s. So, this is 3 R c I d. So, this is an equation that relates V d V d o R c and I d and gamma.

These are the equations for the abnormal operation corresponding to 3 and 4 valve conduction mode ok. Now there is one thing about the range of alpha that is possible with for this abnormal operation. See, in the case of normal operation that is 2 and 3 valve conduction mode, we said that alpha can take any value greater than 0. Now let us see whether that is possible for abnormal operation ok. So, we are still continuing our discussion on the abnormal operation ok.

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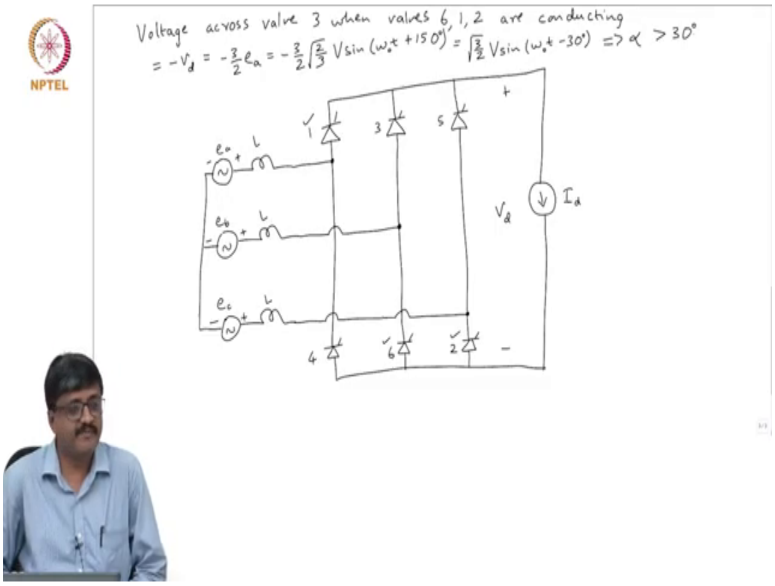

So, if I take voltage across valve 3 when valves 6, see when valve 3 is turned on 6, 1, 2 are already conducting for this abnormal operation. So, valves 6, 1, 2 are conducting. Now what is this voltage when across valve 3 when 6 1 2 are conducting? So, when I sure look at this circuit I mean let me draw the circuit. So, this is a constant current I d e a, e b, e c, L, L, L valves 1, 3, 5 valves 4, 6, 2. So, this is V d. So, 6 1 and 2 are conducting. What is the voltage across R 3?

Student: (Refer Time: 19:33).

Yeah say, in the table we did not actually get the expression for voltage across valve 3. We got the expression for voltage across valve 1. Again for getting voltage across valve 1 we used V d, because V d we had already got. So, it is better to write it in terms of V d and we already know what is V d. We know the expression for V d. So, what is it in terms of V d? Voltage across valve 3, when valves 6, 1, 2 are conducting.

Student: minus (Refer Time: 20:08).

Minus V d. So, it is minus v d. Now, when 6 1 2 are conducting, what is V d ?

Student: (Refer Time: 20:18).

That we make out from the table.

Student: 3 by 2 (Refer Time: 20:21).

3 by 2 e a. So, minus V d is minus 3 by 2 e a ok. Now substitute the expression for ea. What is ea? ea is root 2 by 3 V sin omega o t plus 150. So, it is minus 3 by 2 root 2 by 3 V sin omega o t plus 150 degrees. Of course, I can better to write this as root 3 by 2 V sin omega o t minus 30. I have written just minus sin omega o t plus 150 or sin omega o t minus 30.

So, this is the voltage across valve 3, when valve 6, 1, 2 are conducting. So that means, if I want to turn on valve 3 so, the voltage across valve 3 is given by this expression. So, does I mean what is the inference? I gave a hint; we are talking about the range of alpha. So, can alpha take a value say 10 degrees 5 degrees what is alpha? Alpha is the instant at which valve 3 is stand on.

Student: Greater than 30.

So, it should be greater than 30. See when you want to turn on a valve first of all it should be.

Student: Positive.

Forward.

Student: Forward biased.

Forward biased. So, the voltage across valve 3 will not be negative sorry will not be positive before omega o t will less than 30. So, this actually implies alpha should be greater than 30 degrees. See, there is no point in turning on a valve when it is not forward biased if it is reverse biased it would not turn on ok. So, if you want to turn on a valve. So, and make it I mean I mean allow it to conduct current, then it should be forward biased. So, it will be forward biased only when omega o t is greater than 30. So, alpha should be greater than 30.