DC Power Transmission Systems
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Lecture – 33
Commutation margin angle

Let me give you an exercise that is derivation of the expression for Commutation margin angle psi for different cases.

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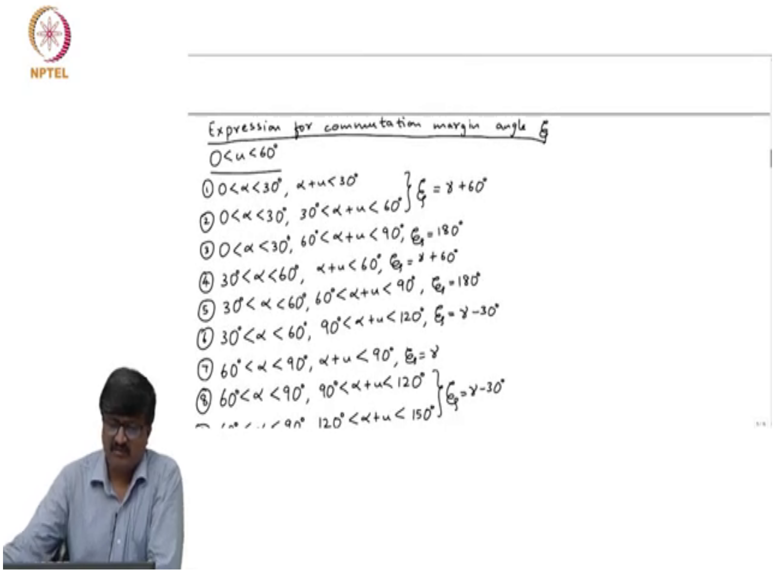

So, what I will do is I will give the answer. I would suggest that you try to derive these expressions: Expression for commutation margin angle psi. So, the expression in fact, depends on the value of alpha and u. So, first let us consider 2 and 3 valve conduction mode, say u between 0 and 60 degrees. Then what are the expressions for the commutation margin angle for different possible values of alpha and u? So, what I would suggest is I will suggest some ranges for alpha and alpha plus u and for each case I asked you to derive the expression for the commutation margin angle.

So, let me take all the cases. So, the first case is alpha greater than 0 and less than 30 degrees and alpha plus u is less than 30 degrees. Suppose, alpha is between 0 and 30 degrees and alpha plus u is between 30 degrees and 60 degrees then alpha between 0 and 30 degrees then alpha plus u between 60 degrees and 90 degrees.

Then alpha between 30 degrees and 60 degrees and alpha plus u is less than 60 degrees; alpha between 30 degrees and 60 degrees and alpha plus u greater than 60 degrees and less than 90 degrees; alpha between 30 degrees and 60 degrees alpha plus u greater than 90 degrees and less than 120 degrees.

Alpha between 60 degrees and 90 degrees, alpha plus u less than 90 degrees then alpha between 60 degrees 90 and 90 degrees alpha plus u greater than 90 degrees and less than 120 degrees. Then alpha between 60 and 90 degrees, alpha plus u greater than 120 degrees and less than 150 degrees.

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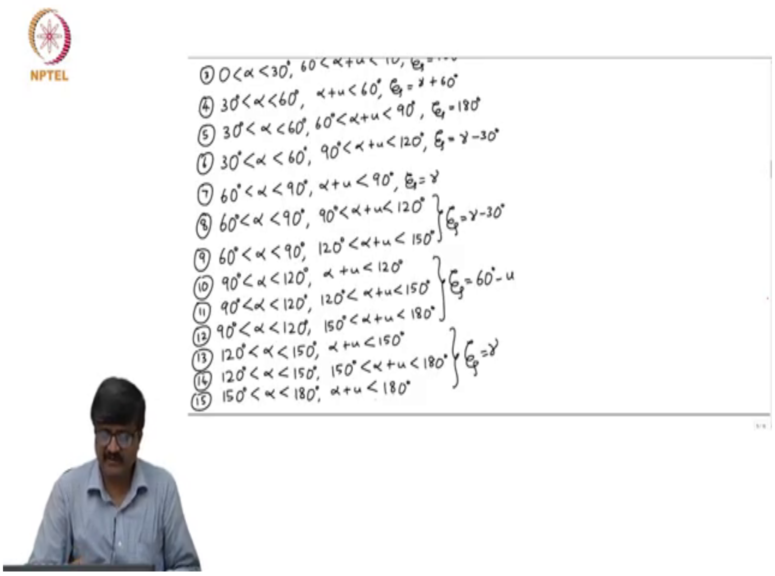

Then alpha between 90 degrees and 120 degrees and alpha plus u less than 120 degrees. Then alpha between 90 and 120 degrees, alpha plus u greater than 120 degrees and less than 150 degrees. Then alpha between 0, sorry alpha between 90 degrees and 120 degrees alpha plus u greater than 150 degrees less than 180 degrees.

Then alpha between 120 degrees and 150 degrees, alpha plus u less than 150 degrees. Then alpha between 120 degrees and 150 degrees, alpha plus u greater than 150 degrees and less than 180 degrees and finally, alpha between 150 degrees and 180 degrees and alpha plus u less than 180 degrees.

So, I am suggesting these are the possible ranges of alpha and alpha plus u, for which I would suggest that you derive the expression for the commutation margin angle. So, I will give the answer. So, I will leave it to you to show that these expressions can be obtained. So, in the first case and second case in both these cases I get the commutation margin angle psi is gamma plus 60 degrees.

Then for the third case, psi is 180 degrees, in the fourth case psi the commutation margin angle is gamma plus 6 degrees, then for alpha between 30 and 60 degrees and alpha plus u greater than 60 and less than 90 degrees psi is 180 degrees, then for alpha between 30 degrees and 60 degrees and alpha plus u between 90 and 120 degrees psi is gamma minus 30 degrees.

In the next case psi is gamma then for the next 2 cases alpha between 60 and 90 degrees and alpha plus u between 90 and 150 degrees, psi is gamma minus 30 degrees and for the next 3 cases psi is 60 degree minus u. So, I am writing this in terms of u. So, whenever alpha is between 90 and 120 degrees and alpha plus u less than 180 degrees, I get psi is equal to 60 degree minus u.

Then in the last 3 cases, the commutation margin angle is gamma. So, how do we derive this expressions? So, what one has to do is we have expressions for the voltage across valve 1 for the different sub intervals. So, take all these expressions and plot them and over that trace the voltage across valve 1 depending on the values of alpha and alpha plus u.

So, by doing so, we get the plot of voltage across valve 1 and from that one can actually find the expression for the computation margin angle. So, you would have notice that even if alpha is greater than 120 degrees, alpha plus u is actually less than 180 degrees. So, we though allow u to take any value up 60 degree alpha plus u cannot exceed 180 degrees. So, let us see why.

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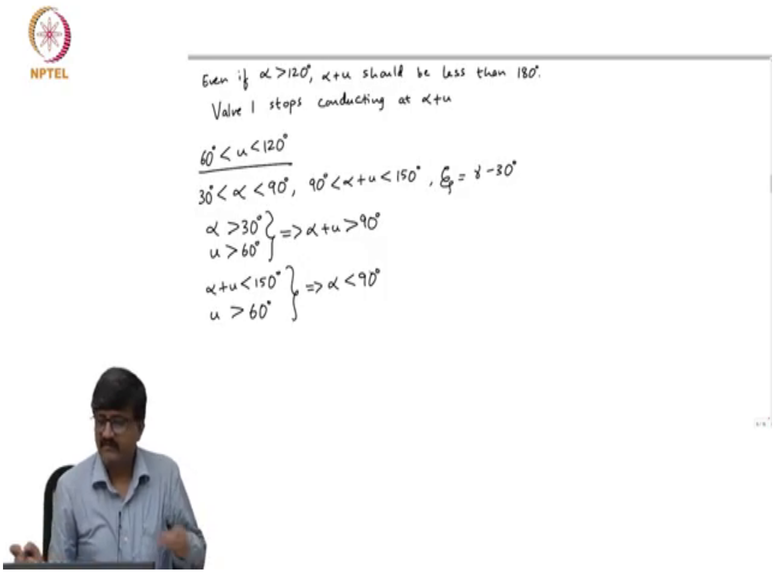

So, even if alpha is greater than 120 degrees alpha plus u should be less than 180 degrees. Now why is it so? Now this is because valve 1 stops conducting at alpha plus u. Now, the condition of minimum value of the commutation margin angle I mean requires that alpha plus u should be less than 180 degrees. So, the reason is same as what was mentioned for normal inverter operation while deriving the expression for the commutation margin angle psi as gamma.

So, I would suggest that you derive these expressions for the commutation margin angle in the case of u between 0 160 degrees. Suppose u is between 60 degrees and 120 degrees then what is the commutation margin angle? Now, we know that whenever u is greater than 60 degrees alpha should be greater than 30 degrees.

And we can show that alpha cannot go beyond 90 degrees and alpha plus u cannot be greater than 150 degrees and it has to be greater than 90 degrees. Now, this is the only possible range of alpha and only possible range of alpha plus u. So, for this one can show that the commutation margin angle is gamma minus 30 degrees

Now, why do we have this range of alpha and alpha plus u? Of course, we already seen why alpha should be greater than 30 degrees, now it is easy to show why alpha should be less than 90 degrees and it is also easy to show why alpha plus u should be greater than 90. Now, it is very easy to show why it should be greater than 90 alpha plus u.

If alpha is greater than 30 degrees and u is greater than 60 degrees, now from this we get alpha plus u should be greater than 90 degrees ok. Similarly, if we show why alpha plus u is less than 150 then we can also show why alpha should be less than 90. See if I can show why alpha plus u is less than 150, this is yet to be shown and we already know that u should be greater than 60 degrees.

Now, from these 2 we can say that alpha should be less than 90, but it is yet to be shown why alpha plus u is required to be less than 150 degrees. So, I mean the I mean it is very easy to show this.

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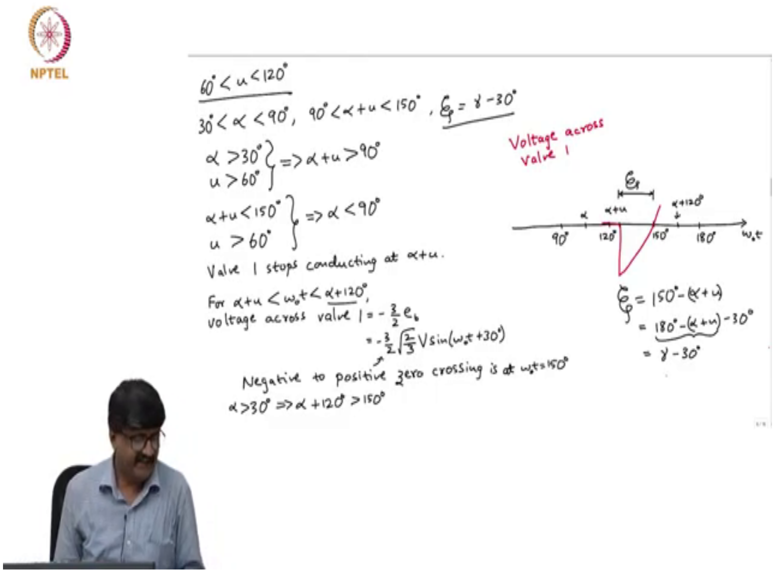

Suppose I take the voltage across valve 1, so, valve 1 stops conducting at alpha plus u. So, that means, up to alpha plus u voltage across valve 1 is 0. So, I will I mean let me also plot the voltage across valve 1. So, let me show some values on the omega o t axis. Suppose this is 90 degrees, this is 120 degrees, this is 150 degrees, say this is 180 degrees, so, alpha plus u is greater than 90 and if I take omega o t greater than alpha plus u and less than alpha plus 120 degrees.

So, for this range of omega o t what is the voltage across valve 1, voltage across valve 1? So, we have seen this expression. So, voltage across valve 1 is minus 3 by 2 e b. So, that is nothing but minus 3 by 2 root 2 by 3 V sin omega o t plus 30 degrees. So, this is the expression for the voltage across valve 1 from alpha plus u to alpha plus 120 degrees.

So, this voltage has a negative to positive 0 crossing at 150 degrees. So, negative to positive 0 crossing is at omega o t equal to 150 degrees ok. Now, alpha is in fact, greater than 30. So, alpha plus 120 should be greater than 150 degrees. So, alpha is greater than 30 degrees actually means, alpha plus 120 degrees is greater than 150 degrees.

See this alpha plus 120 is appearing here ok. So, if I try to plot the voltage across valve 1 from alpha plus u to alpha plus 120 and I just now shown that alpha plus 120 is greater than 150. So, it is valid till the instant which is beyond the 0 crossing beyond the negative to positive 0 crossing. So, let me try to plot the voltage across valve 1.

Suppose, I have alpha plus u somewhere here ok, alpha is greater than 90 and hence alpha plus u is also greater than 90, but it should be less than 150. Now, we will see why it should be less than 150. So, up to alpha plus u the voltage across valve 1 is 0 then it is minus 3 by 2 e b. So, minus 3 by 2 e b has a negative to positive 0 crossing at 150 degrees.

So, since suppose I have somewhere here alpha plus 120 somewhere here, so, up to alpha plus 120 degrees this expression minus 3 by 2 e b is applicable for voltage across valve 1. So, if I want to know the commutation margin angle, so, the commutation margin angle is the duration between these 2 instance the instant at which the valve 1 stops conducting and the instant at which there is a 0 crossing negative to positive 0 crossing of the voltage across valve 1.

So, this is the commutation margin angle psi. So, this commutation margin angle is seen to be equal to 150 degrees minus alpha plus u. So, this can be written as 180 degree minus alpha plus u minus 30 degrees. So, 180 degree minus alpha plus u is nothing but gamma.

So, the commutation margin angle is gamma minus 30 degrees that is what I have written earlier. So, this also shows why alpha plus u should be less than 150 digress, otherwise we do not meet the requirement of having a minimum value of the commutation margin angle. So, alpha plus u should be less than 150 degrees. So, from that I can get alpha to be less than 90 degrees ok.