DC Power Transmission Systems
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Lecture – 27
Extinction angle: Commutation margin angle for normal inverter operation of 6 pulse LCC

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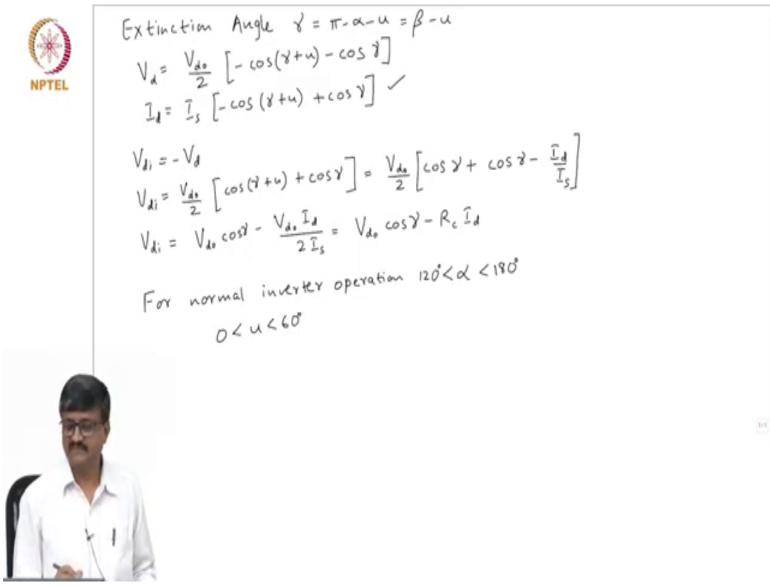

So, we defined a quantity called Extinction angle denoted by gamma. The definition is 180 degrees or pi minus alpha u, it is also equal to beta minus u. So, can you please let me know we got the expression for Vd in terms of a gamma and u and V d o.

Student: (Refer Time: 00:56).

So, did we get this equation V d equal to V d o by 2 minus cos gamma plus u minus cos gamma. Then did we relate I d I s gamma and u?

Student: (Refer Time: 01:17).

So, we go to this relation: I s is equal to minus cos gamma plus u plus gamma plus cos gamma.

Student: (Refer Time: 01:30).

Then we defined a quantity V di which is equal to minus V d. Now, this is a notation which is used for inverter operation V di. So, that subscript i is for a inverter. So, for inverter the DC side voltage has an average value which is negative. So, we take the negative of that, so, that we get a positive value. So, V di is a quantity I mean which is used only for inverter, it is a positive value ok.

So, if you look at V di, so, V di is equal to minus V d. So, from the first equation, I can write this as V do by 2 cos gamma plus u plus cos gamma. Now, what I do is I write this as V do by 2 into cos gamma plus for cos gamma plus u, I use a previous equation. I used the previous equation which relates I d I s gamma and u. So, if I use this equation, I get an expression for cos gamma plus u it is nothing, but cos gamma minus I d by s. So, from this equation, cos gamma plus u is cos gamma minus I d by I s ok.

So, this is equal to. So, finally, we get as V di as V do by 2 into cos gamma plus cos gamma V do cos gamma minus V do I d divided by 2 I s. So, I write this as V do cos gamma minus if you recall we had defined a quantity called rc denoted by rc which is nothing, but V do by 2 I s. So, I can write this as Rc I d.

So, Rc is the equivalent commutation resistance which is a defined as the ratio of V do to 2 I s ok. So, that relates a V di V do gamma Rc I d. Now, why we need this definition gamma? There is a purpose for all the definitions. See if you look at the previous definitions alpha is a straightforward thing I mean it was the delay angle. Why was beta required? What is the definition of beta? 180 minus alpha. Now, what did we need that definition? Now, that was because if you look at the commutation margin angle, the commutation margin angle is more relevant for inverter.

So, if you take the case of u equal to 0 or l equal to 0, the simplest case the ideal case of l equal to 0; say we studied that case only for the sake of starting with the simplified case, so that we do not jump directly to complications in practice there is a non-zero l. So, when l is 0 what is the commutation margin angle? There is one more notation psi commutation margin angle, the duration for which the voltage across a valve is negative after it stops conducting. So, that should have some minimum value. So, that psi was equal to. So, for inverter operation.

Student: 180 minus (Refer Time: 05:55).

So, its 180 minus alpha that is nothing, but beta. So, the purpose for defining beta was it is nothing, but the commutation margin angle; beta is nothing, but the commutation angle for inverter operation. So, for inverter operation, the commutation margin angle is relevant. Say for a rectifier operation actually it is not. So, say for alpha less than 60 degrees you get actually a rectifier operation, for which the commutation margin angle is not equal to beta; only for inverter operation it is. In fact, for any value of alpha greater than 60, the commutation margin angle is actual equal to beta ok.

So, that was the purpose. Now, we see that the new definition extinction angle also happens to be the commutation margin angle for normal operation. So, here also what is a relevant is inverter operation. So, we normally get the commutation margin angle almost close to the minimum required. Say the commutation margin angle should not go below a certain value. So, there is some threshold value. So, it can go near only for inverter operation.

So if I consider normal inverter operation; for normal inverter operation, see normal means what happens in practice normally. See abnormal means due to some fault or I mean due to some unforeseen situation you can have an inverter operation which is not normal, but most of the time it is normal. So, for normal inverter operation what we have is alpha; see I did not say what is the range of alpha for normal inverter operation, ok.

So, I am just making a statement, we will look at more details of what should be alpha for inverter operation. Now, it is not as simple as the case of l equal to 0. So, for l equal to 0 there was only alpha was the only angle. So, if alpha is less than 90, it is rectifier operation greater than 90 inverter operation.

Now, it is not just alpha there is also a u. So, it is not straightforward, but what I would say is I am not talking about the range of alpha for inverter operation, I am just saying the range of alpha for normal inverter operation. So, it is actually greater than 120 degrees and less than 180 degrees.

Of course, it is much less than 180 degrees, its I mean it cannot go near 180, but what I am trying to say is the maximum value is of course, less than 180. Now, let us see what is the commutation margin angle for normal inverter operation and of course, we also have u; u is an angle which is between 0 and 60 degrees. So, let us see why we define a quantity called extinction angle gamma.

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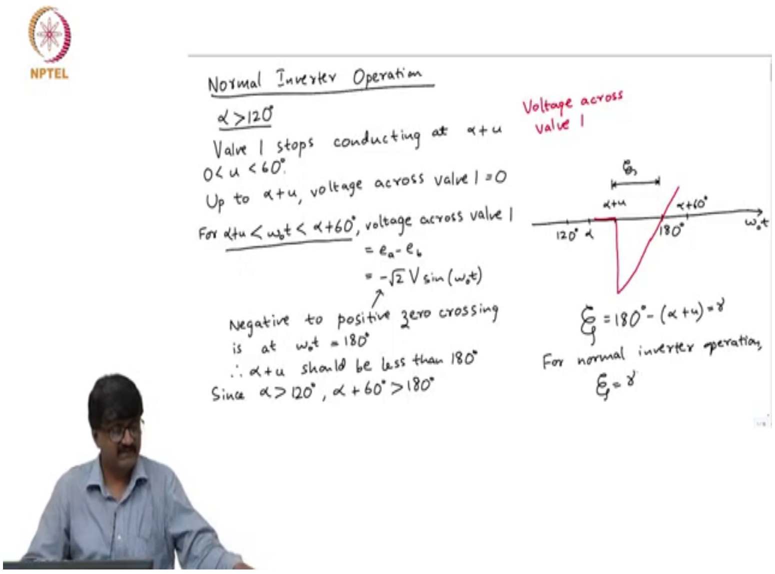

So, if I consider normal inverter operation, so for normal inverter operation alpha is greater than 120 degrees. So, if I take the voltage across say valve 1, so, valve 1 stops conducting at alpha plus u, where u is the overlap angle and u is greater than 0 and less than 60 degrees. So, it actually means that up to alpha plus u voltage across valve 1 is 0.

So, what happens after alpha plus u? So, if I consider a omega o t greater than alpha plus u and less than alpha plus 60 degrees, so, in this duration what is the voltage across valve 1? This is the duration immediately after valve 1 stops conducting, so, voltage across valve 1. So, this voltage is e a minus e b. So, e a minus e b is a line voltage, so it is equal to minus root 2 V sine omega o t. So, this voltage across valve 1 has a negative to positive 0 crossing at omega o t equal to 180 degrees. So, the negative to positive 0 crossing of this voltage across valve 1 is at omega o t equal to 180 degrees.

So, this actually gives the reason for alpha plus u to be less than 180 degrees. So, otherwise the voltage across valve 1 will not be negative after it stops conducting. So, therefore, alpha plus u should be less than 180 degrees. Of course, if I try to plot the voltage across valve 1. So, let me plot this voltage across valve 1; voltage across valve 1. So, if I take the voltage across valve 1 up to alpha plus u this voltage is 0. So, let me show a few values of omega o t suppose this is say 120 degrees.

So, alpha should be greater than 120 degrees and this is 180 degrees. Now, since alpha is greater than 120 degrees, alpha plus 60 degrees is greater than 180 degrees, so that means, I consider this range of omega o t between all alpha plus u and alpha plus 60 degrees. So, alpha plus 60 degrees is actually greater than 180 degrees. So, alpha plus u is between 120 and 180 degrees. So, for the sake of having a minimum value of the commutation margin angle, I should have alpha plus u less than 180 degrees.

So, if I plot the voltage across valve 1, so, up to alpha plus u. Suppose, I show alpha here then alpha plus 60 degrees is greater than 180 degrees because alpha is assumed to be greater than 120 degrees which is true for normal inverter operation. So, this is alpha plus 60 degrees. So, at some instant alpha plus u valve 1 stops conducting.

So, the voltage across valve 1 is 0 up to alpha plus u then the voltage across valve 1 is minus root 2 V sin omega o t. So, it is a wave form like this. So, this wave form is applicable up to alpha plus 60 degrees. So, if you look at the commutation margin angle that is the duration for which the voltage across valve 1 is negative after it stops conducting. So, this duration is the commutation margin angle psi.

So, if we look at the commutation margin angle psi then we can see that this is equal to 180 degrees minus alpha plus u now which is nothing, but the angle that we have defined as a gamma extinction angle which is given by 180 degrees minus alpha plus u. So, we see that whenever we have normal inverter operation the commutation margin angle is gamma. So, that is the purpose of defining this quantity gamma and is called extinction angle. So, for normal inverter operation the commutation margin angle psi is equal to gamma.