DC Power Transmission Systems
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Lecture - 18
Commutation margin angle in a 6 pulse LCC neglecting inductance: Part 2

So, we are looking at what happens to the Commutation margin angle. So, we already saw if alpha is greater than 60, the commutation margin angle is nothing, but beta or 180 minus alpha. On the other hand if alpha is less than 60; so let us draw the waveform.

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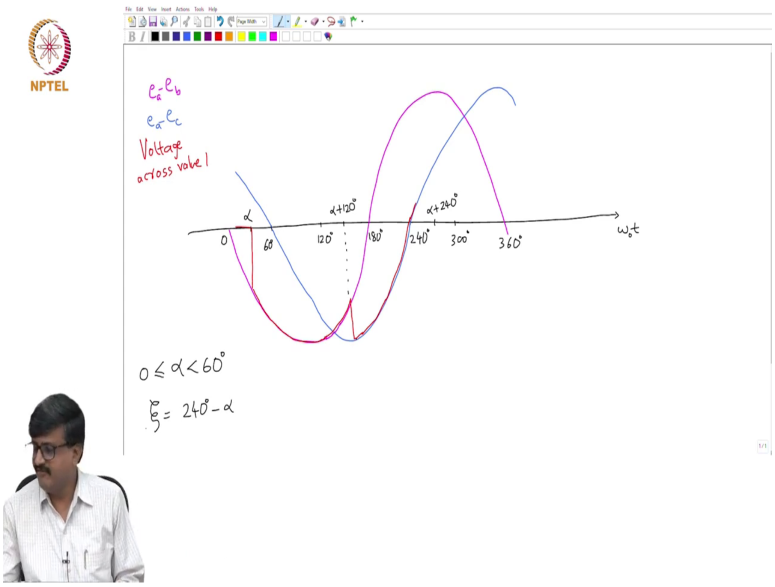

So, the possible expressions for voltage across one of the valve say valve 1 is e a minus e b or e a minus e c.

So, if you look at the expression for e a minus e b; e a minus e b is minus root 2 V sin omega o t; so just mark every 60 degrees. So, this is e a minus e b ; so this is 0. So, if you look at e a minus e c; so if I draw e a minus e c, e a minus e c lacks e a minus e b by I can get an expression. So, we saw that it lacks e a minus e b by 60 degrees; so this is e a minus e c.

So, if I want to plot the voltage across valve 1. So, we will consider the case of alpha less than 60 and of course, greater than 0 ok. So, I cannot; in fact, consider e equal to 0. So, I have 60 degrees here, 120 here, 180, 240, 300, 360 degrees.

So, if alpha is less than 60 degrees; then I have to show alpha somewhere between 0 and 60 degrees ok. So, suppose alpha is somewhere here; so just before turning on valve 3; alpha is the instant of turning on valve three. So, that is for omega o t slightly below alpha, what is the voltage across valve 1 ?

Student: e a minus e b.

Voltage across valve 1.

Student: Just before.

Just before turning on.

Student: Just before,

Yeah just before valve 3 is turned on valve 3 is turned on at alpha; so it is 0. So, it is 0. So, as soon as valve 3 is turned on, the voltage across valve 1 is?

Student: e a minus e b.

e a minus e b; so just jumps to e a minus e b. So, for how long it will be e a minus e b; up to?

Student: Alpha plus 120.

Alpha plus 120 ok; so alpha plus 120; so where is alpha plus 120? It comes after?

Student: 120.

Student: Between 120 and.

Between 120 and?

Student: 180.

180 yeah; so alpha plus 120 is here. So, up to alpha plus 120; voltage across valve 1 is e a minus e b. Then at alpha plus 120, voltage across valve 1 jumps to?

Student: e a minus e c.

e a minus e c; then it remains at e a minus e c up to?

Student: Alpha plus 240.

Alpha plus 240; that is after alpha plus 240 is between 240 and 300. So, this is alpha plus 240. So, it remains at e a minus e c to the (Refer Time: 06:04). So, after turning off; say turning off of valve 1 is by itself because current goes to 0. So, as soon as valve 3 is turned on, valve 1 goes off.

So, if I look at the voltage across valve 1; after it stops conducting at? When does it stop conducting? At valve 1, when does valve 1; see we are interested in voltage across valve 1. So, as long as it is conducting; the voltage across the valve 1 is 0 ok, it is nonzero ?

Student: (Refer Time: 06:35).

If it is not conducting and as soon as it stops conducting, the voltage should be negative for a minimum duration.

Student: Duration.

So, that minimum duration required is actually denoted by a psi naught. So, a typical value of psi naught is 15 degree for 50 Hertz ok. So, what can I mean; what is the value of commutation margin angle? Commutation margin angle is the actual value of the angle for which the voltage across valve 1 is negative. So, this duration is decided by the 0 crossing of e a minus e c. So, in the previous case when alpha is greater than 60, it was decided by the 0 crossing of e a minus e b.

So, can you get an expression for the commutation margin angle psi ; 240 minus 240 degree minus alpha. So, we have two values of commutation margin angle; either it is 180 minus alpha or it is 240 minus alpha.

Now, the question is in the case of alpha being greater than 60; I had in fact, a smaller value I mean of course, smaller big of course, smaller or larger depends in fact on alpha. Now, the question is which one is more relevant? See, whether alpha is between 0 and 60 is relevant or alpha greater than 60 is relevant. See which one is more critical say?.

More critical means there is a chance of this commutation margin angle this psi becoming less than the minimum required valve; that should not be allowed. So, psi should take some minimum value, it should not go below that. So, I mean whether it is likely to happen for alpha greater than 60 or alpha less than 60?

Student: Greater than 60.

Alpha greater than 60. Now, for alpha less than 60; you see that I mean it is say alpha is I mean something which cannot go beyond 60. So, it is very unlikely that psi I said a typical value say 15 degrees, it is very unlikely that this psi will go; it is impossible in fact.

Student: Yeah, its (Refer Time: 08:54).

It is impossible; it is impossible for psi to?

Student: Cross on it

Yeah, I mean it to go below the required value. So, there is a chance of psi going below the required commutation margin angle, going below the typical value of say 15 degree which is minimum; only in the case of alpha greater than 60 ok. now ; that means, for rectifier operation; see even for alpha greater than 60, if alpha is I mean what is the maximum value of.

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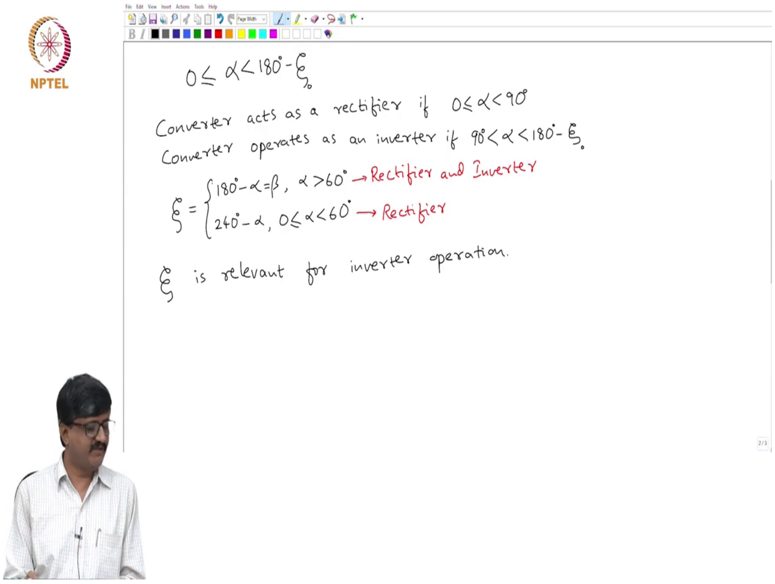

In the last class we saw alpha can take any value between 0 and what is the maximum value?

Student: 180.

180 degree ?

Student: Minus psi.

Minus psi naught.

Student: minus psi.

Ok, so we saw that there is one more thing based on the sign of the average value of V d; we could conclude that for some values of alpha; the converter operates as a rectifier. See converter acts as a rectifier I mean I could we conclude this, based on the?

Student: Sin of.

Sin of?

Student: Sin of voltage.

Sin of?

Student: Voltage.

Voltage, which voltage?

Student: V d.

Which voltage?

Student: (Refer Time: 10:27).

I mean, what is out there is no output input say a converter has AC side DC side.

Student: DC voltage.

We talk only in terms of ; I am see output you are trying to assume that the converter is always rectifier ok. So, we do not use the word output or input; I mean power can flow either from the AC side to DC side or DC side to AC side that is why we always use the word converter, converter is a general term. So, it can operate as a rectifier or operate as a inverter.

So, converter operates as a rectifier; if alpha is between?

Student: 0 to pi by 2.

0 to pi by 2; see for alpha between 0 and 90 degrees; we get positive value for what? DC side? Sorry.

Student: DC side.

DC side?

Student: Average.

Average voltage ok; the for the average value of the DC side voltage, I mean the average value of the DC side voltage tells us whether the converter is operating as a rectifier or not. Because the current on the DC side is a constant current in one particular direction; so if I have positive average value then I get rectifier operation.

Now, when does it operate as inverter? So, converter operates as an inverter if alpha is greater than 90 degrees; obviously, alpha equal to 90 degrees does not correspond to either I mean either inverter operation or rectifier operation because.

Student: Power is.

Power is?

Student: Power is 0.

Power is 0.

Student: No power

No power ok. So, what is the upper limit on alpha?

Student: 180 degree.

180 degree. So, it is not 180 degrees; it is 180 degree minus.

Student: Psi naught.

Psi naught; psi naught. So, now coming back to this question of for what values of alpha; the commutation margin angle expression is I mean; commutation margin angle is relevant only for what operation? Whether its rectifier or inverter?

See alpha less than 60 degrees; we got two expressions for commutation margin angle let me write them. Commutation margin angle has two expressions; either it is equal to 180 degree minus alpha which is nothing, but beta or it is equal to 240 degree minus alpha.

So, the first expression is applicable if alpha is greater than 60 degrees and the second expression is applicable for alpha between 0 and 60 degrees ok. So, what is relevant for us as far as commutation margin angle is concerned is alpha greater than 60. So, alpha less than 60 corresponds to rectifier operation; please note that alpha less than 60. In fact, alpha less than 90 corresponds to rectifier operation.

So, this actually corresponds to rectifier operation; whereas, alpha greater than 60 corresponds to both rectifier and inverter because from 60 to 90, it is rectifier and beyond 90 it is inverter ok. So, this corresponds to both rectifier and inverter operation.

Now, when does this value of psi matter; the commutation margin angle when alpha is less than 90 or greater than 90?

Student: Greater than 90.

Yeah it is in fact greater than 90. In fact, when it is going close to 90 degrees so; that means the commutation margin angle matters for inverter operation ok. So, psi is relevant for inverter operation.

So, when simplified analysis was done for the first time that is no inductance, the notation beta itself was used for psi. Because it was not necessary to have the expression for alpha less than 60 and we; we know that for alpha greater than 60, it is beta. So, the purpose of this notation beta was because the; the simplified analysis with the inductance l equal to 0; beta is nothing, but the commutation margin angle. So, which is actually true for inverter operation and of course, the commutation margin angle is not relevant for rectifier operation is that ok; yeah.