DC Power Transmission Systems
Prof. Krishna S
Department of Electrical Engineering
Indian Institute of Technology, Madras

Lecture - 11
Analysis of 6 pulse LCC neglecting inductance: Average DC side voltage

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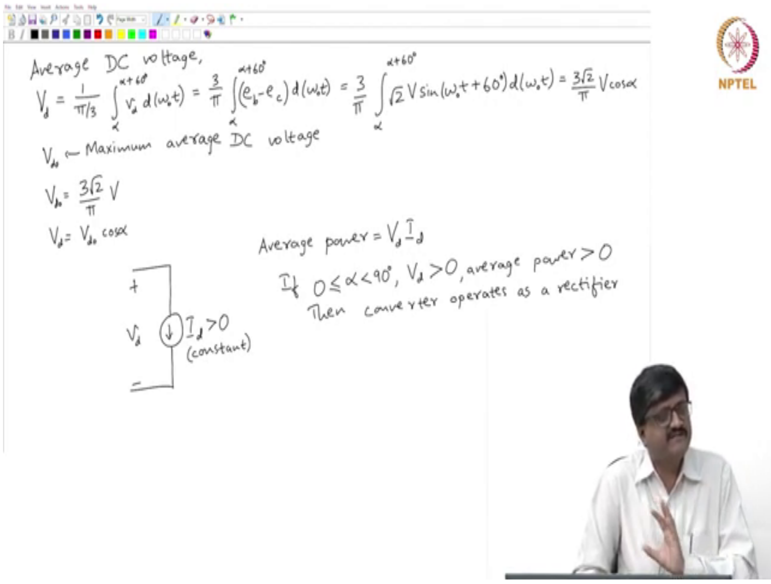

That is the average DC voltage, average DC voltage or average DC side voltage. So, we use a notation for this V uppercase V with a subscript d. Now, can I use the table and try to get a average value of the DC side voltage? If there is 1 cycle and in 1 cycle there are 6 intervals, the waveform of the DC side voltage actually repeats 6 times, is that a result well known to you?

Student: Yes.

So, I use that information. So, I know that there is I mean there are actually 6 intervals in 1 cycle and waveform repeats. So, the frequency of the DC side voltage is 6 times the frequency of the.

Student: AC side.

AC side voltage. So, if I want the average, I need not do an integration over 2 pi radians, I can just do it over 2 pi by 6 radians ok. So, what I can do is I will try to take any 1 interval, 1 interval is of duration 60 degrees that is 2 pi by 6. So, I will just integrate over 1 interval of duration 60 degrees and get the average value. So, 2 pi by 6 or pi by 3, so 1 by pi by 3. So, I can take any of the 6 intervals. Now, so the first interval is from alpha to alpha plus 60 degrees.

So, if I take the first interval in from the table, I have to just substitute for the instantaneous V d ok. So, its integral of alpha to alpha plus 60 degree of V d with respect to omega o t divided by pi by 3, so that is the expression for average DC voltage. So, that is equal to 3 by pi integral from alpha to alpha plus 60 degrees. V d from alpha to alpha plus 60 degrees, you know the expression for V d, the instantaneous V d from alpha to alpha plus 60 degree now when we got.

Student: e b minus e c.

e b minus e c, integrate with respect to omega o t, omega o t is the angle; so or independent variable is angle. So, we are not using time as the independent variable, omega o is the operating value of angular frequency. See that subscript o is for operating value and omega is the usual angular frequency. So, omega o is the operating angular frequency.

So, this is equal to 3 by pi integral alpha to alpha plus 60 degrees and of course, e b minus e c is root 2 V. So, from the expressions for e b and e c I can get the expression for e b minus e c it is sin omega o t plus phase angle which is, so e b is having a phase angle of 30, e c is having a phase angle of minus 90, so minus e c will have a phase angle of.

Student: (Refer Time: 03:40).

Plus.

Student: (Refer Time: 03:43).

Now, can I straight away; see I am can I straight away write the expression for e b minus e c? So, what is it? Plus.

Student: Plus 60 degrees.

Plus 60 degrees yes. So, I mean this is straight forward integration. So, if you integrate this you get and I will leave it to you to derive this 3 root 2 by pi V cos alpha ok. Now, if you recall we had 1 more quantity V d o, do you recall this? This notation V d o there is another subscript o, what is this V d o?

Student: (Refer Time: 04:31).

Sorry.

Student: Average DC voltage (Refer Time: 04:36).

Yeah maximum, so we use this notation in the context of trying to obtain a general converter circuit ok. So, if you use this notation for maximum average DC voltage. So, what is the maximum average DC voltage in this case? Look at the expression for V d V d is the average DC voltage. What is the maximum possible value? So, maximum is obtained by choosing an appropriate value of alpha; so, for a particular value of alpha.

Student: Sir.

If alpha is 0 we get the maximum value. So, that is 3 root 2 by pi into V is the maximum average DC voltage. So, that is V d o. So, therefore, I can relate V d and V d o, V d is V d o cos alpha ok. So, this is something which is applicable for the circuit we considered irrespective of the operation of the converter as a rectifier or an inverter. So, these are not dependent on how the converter operates; whether it operates as a rectifier or an inverter. Now we have to see, when we get rectifier operation and when we do not get rectifier operation or when we get inverter operation? So, when do we get rectifier operation?

Student: (Refer Time: 06:14).

Alpha is.

Student: Less (Refer Time: 06:17).

Less than.

Student: 90.

90. So, you see on the DC side, if you look at the DC side of the converter our assumption is a constant current. So, the DC side has a plus terminal and a minus terminal the voltage across the DC side is V d. So, I am not drawing the entire circuit diagram, the DC side of the converter has 2 terminals ok, the voltage across the terminals is V d. And I have a current id of course, id is positive please note id is positive it's a current source is positive so; that means, the converter acts as a rectifier, if the average power is flowing from the AC to DC side, that is the definition of rectifier ok.

So, a converter has distinguishable AC sides and DC side. AC side has 3 terminals, we always work with 3 phase of course, as far as this course is concerned and DC side has 2 terminals. So, if the average power flow is from AC to DC side then we say the converter acting as a rectifier, if the average power flow is from DC to AC side it is said to operate as an inverter. So, that is the definition. So, if I look at the average power, what is the average power?

Student: (Refer Time: 07:39).

It is nothing, but the average voltage into the current that is the average power current is anyhow constant current is a constant value. Please note this id is constant, that is our assumption ok. So, if average power has to be positive then what should be the value of alpha? So, if alpha is greater than or equal to 0. I am sorry if alpha is greater than or equal to 0 and less than 90 degrees, then V d is positive. Yeah, there are 2 V ds, one should be careful I hope I am able to differentiate between the instantaneous V d by using a lowercase V and an uppercase V by for the average value. So, the average value of V d should be greater than 0, only then the average power is ok.

So, if alpha is between or in fact, even equal to 0 greater than or equal to 0 and less than 90, then V d is positive and average power is positive, average power is positive. So, then the converter operates as a rectifier, then converter operates as a rectifier. Now, if it is equal to 90, if alpha is 90.

Student: (Refer Time: 09:40) neither.

Its neither a rectifier nor a inverter, there is no power flow both; I mean when V d is 0 power is 0 ok. Suppose alpha is greater than 90, then we get a negative value of V d, if alpha is greater than 90 we get a negative value of the average value of the DC side voltage then the power is actually flowing in the other directions then it the converter is said to operate as an inverter.

Now, we will come to that later because, I know that if alpha is greater than 90 it is inverter operation, but I still do not know for the timing being up to what value of alpha I can go. So, I will come to that a bit later. So, inverter operation will be considered just shortly, but later. So, these are a few things which we are able to obtain from the table that we obtained in the last class ok. Now, there is a something on the AC side, say ideally on the AC side we should have voltages and currents that are sinusoidal on the DC side voltage and current should be constant.

Now, if you look at the AC side of the converter, the voltages are sinusoidal on the DC side current is constant, but the voltage on the DC side is not constant, I mean it is not a constant ok. As similarly what about the current on the AC side? The currents are not sinusoidal. So, on the AC side voltages are as required ideal, but currents are not sinusoidal. On the DC side current is ideal by our assumption it is constant, but voltage is not ideal.

So, when we say something is not equal to what is desire, then we want to find out by how much it is deviating from ideal. So, how do we do that? We want to quantify the amount by which the voltage on the DC side is deviating from ideal; from the ideal waveform and we want to quantify the amount by which the current on the AC side is deviating from what is desired. So, how do we do that?

Student: (Refer Time: 11:52).

Sorry.

Student: (Refer Time: 11:54).

Sorry.

Student: (Refer Time: 11:55).

Student: Ripple factor.

Ripple factor, yeah any other suggestion.

Student: DC side is ripple factor AC side is total (Refer Time: 12:09) discussed.

Yeah. So, finally, it is some frequency which is appearing and it should not be there say on the DC side we want only DC quantity, but there are other periodic waveforms. So, the point is there are other periodic waveforms that are appearing on the DC side in the in the case of voltage. On the AC side as well we want only fundamental, but we do not have DC on the AC side, but we have some other harmonic components.

So, a very nice way of trying to quantify this is using what is known as harmonic components and that we can do by the use of Fourier series ok. So, what I will do is, I will try to briefly give the results of Fourier series without we getting into any derivations. So, that you are familiar with the results and one can use directly ok.