DC Power Transmission Systems

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Lecture - 37
Steady state analysis of a general LCC: Part 1

Now, what we will do now is try to do a Steady state analysis of a general converter. So, of course, what is the intention is I mean though we have not studied very general converter, we have studied I mean in detail only one particular converter, but in the same converter we have try to do analysis for different modes. Now, there is a possibility of doing a steady state analysis of a general converter which is applicable for any mode.

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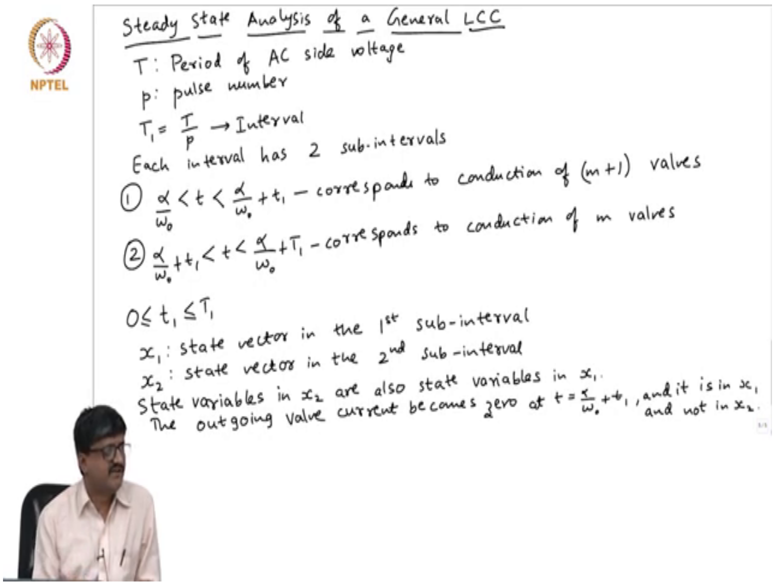

So, we will see how to do that and try to see how one can apply into special cases, steady state analysis of a general Line Commutated Converter. So, it is so far our analysis has been restricted to one particular circuit where, we have 3 legs or 6 valves and on the AC side there is a 3 phase voltage source connected in Y and 3 inductances on the DC side a current source.

Now, there can be some deviations from this. I mean there can be more complexities for example, there can be a resistance on the AC side in addition to inductance, on the DC side instead of a current source there can be a voltage source in series with an inductance or voltage source in series with an inductance and resistance.

Now, these complex cases are not as easy to analyse as we did till now. So, what we have consider till now is a very simple circuit. A current source on the DC side and a voltage source with inductance on the AC side is a very simple circuit; there can be more complicated circuits for which it is not as straight forward as in the easier case to get the steady state analysis.

But what we will do is it is not necessary to take each and every case separately and analyse, we can do a very general analysis and apply it to special cases. So, what we will do is so, we will try to 1st of all use some notations. T is the notation used for the period, this is in this is in seconds or milli seconds, T is the period of AC voltage or AC side voltage. We already use this notation p lower case p for pulse number. So, for the circuit that we studied in detail this pulse number p is?

Student: 6.

6.

Student: 6.

6. So, we will consider another value of pulse number that is 12 much later in the course. Then we define T with a subscript 1 as T by p. So, if T is period what is T 1? I mean period divided by pulse number, what does it give, there is a name for that, what is that? Say in the previous case p was 6. So, if the period is divided by 6, what we get is T 1, what is that, we have been

calling that as? See we are I mean we have been using this name interval, so, if T in degrees is 360 degrees, p is 6 then 360 by 6 is 60 degrees that is interval.

So, T 1 is the interval, but now what we are trying to do is we will we are using some notations, which is corresponding to the period or interval in terms of time instead of angle. Then there are this ok, let me write this; this corresponds to 1 interval. So, each interval has 2 sub intervals; has 2 sub intervals.

Now, the 1st sub interval, we use to take the 1st sub interval as starting from alpha. So, if I take the independent variable as angle that is omega o t then it is alpha, if I take time then it is?

Student: Alpha by.

Alpha by omega alpha by omega o. Then I will call the other end of the 1st subinterval as alpha by omega o plus t 1. So, this sub interval corresponds to conduction of m plus 1 valves, then the 2nd sub interval starts from alpha by omega o plus t 1 to what to what?

Student: plus (Refer Time: 06:05).

Student: o plus (Refer Time: 06:07).

Alpha by omega o plus uppercase T with subscript o. Now, this corresponds to conduction of how many valves?

Student: m valves.

m valves. Now I use a general notation m, m plus 1, I mean that is because this is applicable even if I take one particular converter 6 pulse converter, which we have already studied, it can be 2 and 3 valve conduction mode or 3 and 4 valve conduction mode. So, if it is 2 and 3 valve conduction mode m is 2. If it is 3 and 4 valve conduction mode m is 3.

Of course, this t 1, is obvious that it is less than or equal to uppercase T 1 and greater than or equal to 0. Now, if I take the 1st subinterval, so, please note that in general it can be shown that this circuit is linear. So, far also the special cases that we considered whether it is 2 and 3 valve conduction mode or 3 and 4 valve conduction mode of the simple 6 pulse converter that we studied, it is a linear circuit.

So, the equations governing the system are linear differential equations and not only that they are linear with constant coefficients as well. See there is a difference between linear constant linear time invariant system, linear time varying system. So, the equations that we come across in this course are linear time invariant. So, for which the solution is straight forward.

Now, before going to the equations that govern the circuit in the 2 subintervals, I will use some more notations: x 1 is the notation used for state vector in the 1st subinterval, x 2 is the state vector in the 2nd sub interval ok. Now, can we say anything about the relative sizes of x 1 and x 2? Say state vector, I mean can be considered to be a column vector; can be considered to be a column vector or a column matrix.

So, what about the relative size of x 1, x 2, which one is larger 1st of all, x is larger or x 2 is larger?

Student: (Refer Time: 09:00).

Both are same.

Student: (Refer Time: 09:06).

See based on our understanding of some special cases so far, if I take 2 and 3 valve conduction mode or 3 and 4 valve conduction mode, if you look at the 1st and 2nd subintervals you see that the number of loops is larger in the.

Student: 1st (Refer Time: 09:25).

1st sub interval it is smaller in the 2nd sub interval and the difference is 1. Now, it so happens that it can be shown that x 1 is of course, larger in size compared to x 2 and it is larger by 1.

So, the number of state variables in x 1 are in the 1st sub interval is one larger than the number of state variables in the 2nd sub interval. Now that means, the state variables in the sub 2nd sub interval are also state variables of the 1st sub interval, but one of the 1st subinterval state variable is not a state variable of a 2nd sub interval. Because, there is 1 valve current which goes to 0, so, there is 1 valve current in x 1 which is not appearing in x 2 ok.

So, we will say that state variables, see state variables are nothing but the elements of the state vector. So, state variables in x 2 or also state variables in x 1. So, one state variable which can be considered to be one of the valve current; valve current, becomes as a state variable. That valve current which goes to 0 in the 1st sub interval can be considered as the state variable which is there in x 1, but it is not there in x 2.

So, we say the outgoing valve see outgoing valve means the valve which stops conducting. The outgoing valve current actually becomes 0, at what instant? At t equal to see for the time being I am trying to write equations with independent variable time. It becomes obvious why I am switching to time it becomes obvious quickly.

Student: Consider (Refer Time: 11:36).

At?

Student: Alpha by omega.

Alpha by omega o plus t 1. So, the outgoing valve current becomes 0 at this instant alpha by omega o plus t 1. And it is a state variable of x 1, but not a state variable of x 2 and it is in x 1, it means, what, what is in x 1? The outgoing valve current is in x 1 and not in x 2 ok. So, I can try to write what are known as differential equations. So, if x 1 and x 2 are the state vectors in the 2 sub intervals there are 2 different sets of differential equations with corresponding to our 2 sub intervals.

So, these can be shown to be linear time invariant equations for which the solutions are straight forward. So, we will try to write the equations, the solution and then what we will see is we will know everything in this except for one particular quantity that we are solving for. So, I will not give all the I mean answers right now. So, I will stop at this point, we will continue the analysis of this in the next class.