Introduction to Time-Varying Electrical Networks
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MNA stamps of controlled sources - the VCCS & VCVS

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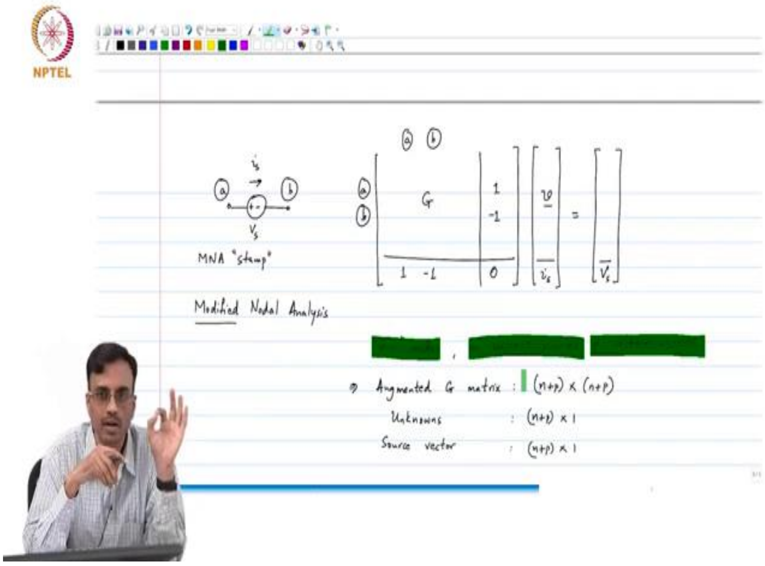

So, once the number of nodes in the network, the number of independent current sources and the number of independent voltage sources. I mean, the job is very straightforward, you first set up a matrix of size n plus p cross n plus p and then you go element by element and to the initialize matrix full of 0s, you just add the stamp of that particular element, if you see a conductance you add to this matrix, you first initialize the 0 cross I mean, n plus p cross n plus p matrix full of 0s, then you go element by element you know the stamp of each element, you just add that stamp to the existing matrix.

So and I mean, there is of course, a simple-minded way of doing this. If you have a huge network, you do not want to create, so much location, so you want do not want to allocate, so much memory at one time and then you can be probably you can do smarter things like, that is a whole that is a different ballgame. It is all about memory management and so on. But at least in principle, you go element by element and then add to the existing all 0s augmented conductance matrix, the stamp of that particular element.

And this is what is done in, in all circuit simulators. Because SPICE will generate a netlist from the schematic that you draw and then the matrix generation is simply you go line by line and then, figure out what element you are trying to plop into the matrix, you know it stamp already. So, you just add that stamp to the Matrix. Of course, we are not happy with just networks with conductance current sources and voltage sources, we are also going to have?

Student: (())(02:32)

Professor: Controlled sources. So, let us see what we can do with controlled sources.

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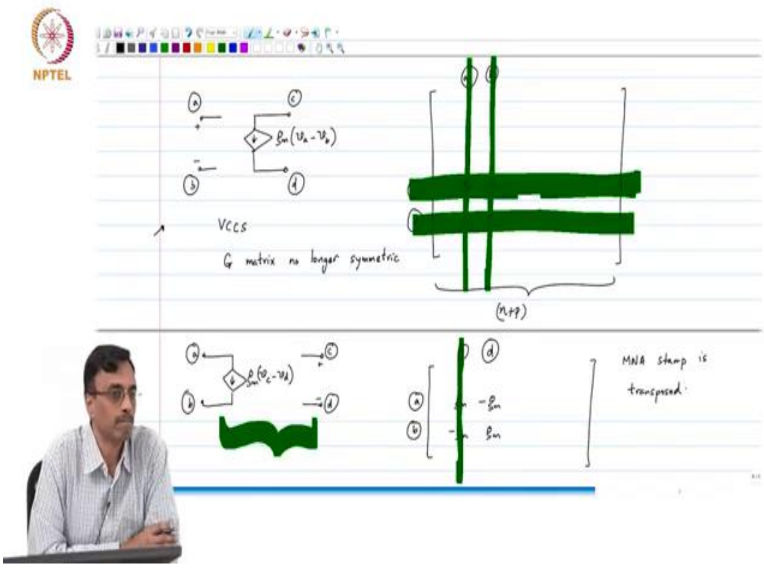

For example, the simplest one to deal with is the voltage-controlled current source. Now, I am not going to sit and draw the entire network, I am just going to focus on the nodes gm times va minus vb, this is the network. This is the controlled source and we have to figure out, remember that we are trying to figure out what the stamp of this controlled sources. So, in general, therefore this augmented conductance matrix will be of this form, it will have, n plus p rows and then n plus p columns and so all the action will be basically between in which rows and which columns?

Student (())(03:43)

Professor: In the rows corresponding to a, b, I mean, if at all there is any action it will be in only in these rows and these columns. So, can you tell me what will happen to in which row we will have the stamp of the voltage controlled current source? Well, the current is flowing between node C and D. So, all the action will be, in the rows which correspond to the cth and dth nodes.

So, all the action will be here in this row. So, we do not have to worry about these two guys and the current depends on which voltages?

Students: (())(04:52)

Professor: Node voltages a and b. So, we do not have to worry about the cth and dth columns. So, the entries will happen here. Does it make sense? And what is the entry in the cth row you have gm into va and minus gm into v, makes sense people and likewise in the dth row what we see? Minus gm. Does it make sense?

So, in other words the augmented conductance matrix, let us call it G sub-capital A, so not to get confused between small A, the abth, let us forget about what I mean. So, you can see therefore that the MNA stamp of the voltage-controlled current source looks largely similar to that of conductance with a key difference and that being.

Student: (())(6:40)

Professor: Well if you had a conductance what would happen? The stamp would look kind of similar. The only difference would be that the cdth row would simply become the same as the?

Student: abth row.

Professor: abth row, I mean and intuitively that makes sense. If I shot these two, how does it look like? If I shot a with c and b with d, what does it look like?

Student: (())(07:03)

Professor: It looks like conductance the value gm and then that basically will appear in the abth row and abth column. Now, what comment can you make about the structure of this matrix now? Earlier when we had only conductances this was?

Student: Symmetric.

Professor: Symmetric. Now it is no longer symmetric. So, with the controlled source I mean it is possible and out of curiosity, if I did this, I mean this is just simply this gm times vc minus vd. So, how will there MNA stamp of this look like? This will happen in the ath and bth rows and in the cth and dth columns and what will happen, this will be gm minus gm and this will be minus gm and gm.

So, what comment can you make about the MNA stamp of this versus this. Whatever was happening in the cth row of this guy is happening in the cth column of this chap. So, if you flip the controlling and control ports, you can see it, it is very clear that the MNA stamp is simply the, what? Simply the transpose. So, just bear this in mind. We will come back to this later. So, we finished the simplest of the control sources.

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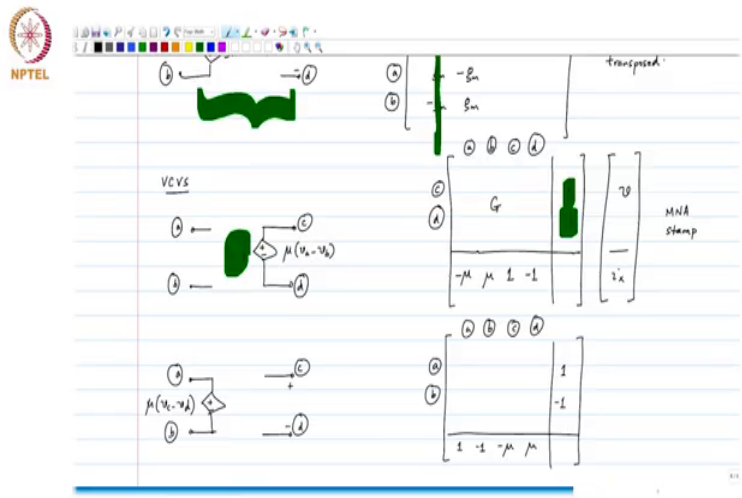

Now, let us see the next controlled source we will talk about is a, the voltage-controlled voltage source and again we are trying to find the MNA stamp of the voltage-controlled voltage source. So, let us call its gain, it occurs between these four. So, let us call the gain mu times va minus vb, again. So, we have a voltage source and what is the problem with a voltage source? That is controlled or uncontrolled, I mean what happens? The current is an unknown. So, you need to add an extra unknown to the set of equations.

So and this current I am going to call let us say is, I mean ix and therefore, what should we do, how will the MNA stamp of this looks like? We had the original G matrix. Now, we need to add an extra, we have the node voltage vector and then we have to add an extra unknown ix and which rows will all the action be happening, in c and d and which column of these rows will all the action be happening? Which column do you think all the action is happening?

Students: (())(12:25)

Professor: In the last column. So, that is basically the cth row should have a plus 1 and the dth row should have a minus 1.

Student: (())(12:43)

No, no this model c, this is the current. So, that is ix is flowing I mean these entries model the fact that, a current ix is flowing from out of node C and then-current ix is flowing into node D. So, we have an extra unknown. So, we need an extra equation, what is that extra equation?

Student: vc minus

Professor: vc minus vd is nothing but mu times va minus vb or in other words, vc minus vd minus mu times va minus vb equals 0. So, where all does the action happen? Now, that happens in the last row. Which all columns, do you see the action happening a, b, b, c and d. So, c must be 1, d must be minus 1, a must be minus mu and b must be plus 1.

So, this is the MNA stamp of or the voltage-controlled voltage source and now out of curiosity what I am going to do is see what happens when I just flip the voltage source the controlling and controlled ports around. So, this is now mu times vc minus vd and this is vc this is vd. So, what comment can you make about this matrix now. So, in which must this, which of those rows will be affected?

Students: A and B.

Professor: A and B and what do you see? People come on.

Student: (())(15:26)

Professor: So, in the last column you will basically see, 1 and?

Student: (())(15:30)

Professor: Minus 1 and what about all the columns basically have a, b, c, and d and what do you see?

Student: 1 minus 1 (())(15:42).

Professor: 1

Student: (())(15:47)

Professor: Minus 1

Student: (())(15:49)

Professor: minus mu

Student: Plus mu.

Professor: Plus mu. So, stop here, we will start in the next class. So, tomorrow at 8 o'clock class, please show up on time, do not walk in and argue.