Network Analysis
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Lecture # 06
Nodal Analysis-I

Welcome to lecture number 6 and we have been discussing 2 very popular method of solving a network problem. Of course, as I told you earlier that I will be considering to begin with.

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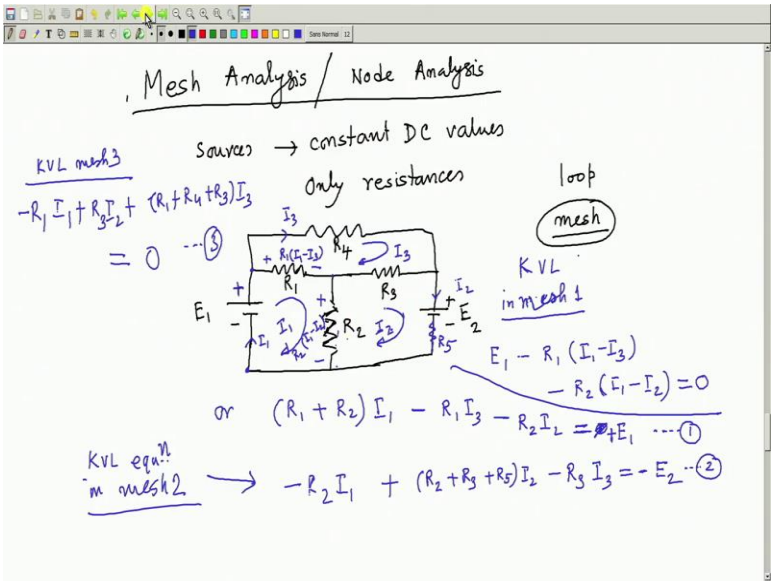

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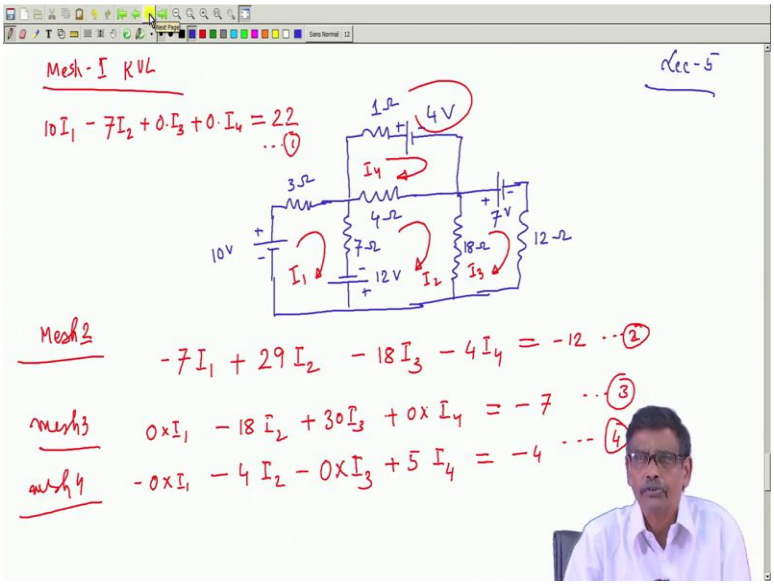

DC sources to be present only and all the resistances are there of course, that I will remove soon, that restriction just to get an idea how we applied this method to solve this network. Main thing is that in mesh analysis identify the number of messes. In general number of equations to be solved is equal to the number of messes algebraic equation, and if you are lucky in mesh analysis. If can reduce the number of equations to be solved, provided there exists some current sources in the outer meshes.

If you can identify some mesh where after this nothing is present then that mesh current is known that is there were only for example 2 messes are there we have to solve only 1 question, this mess current being known.

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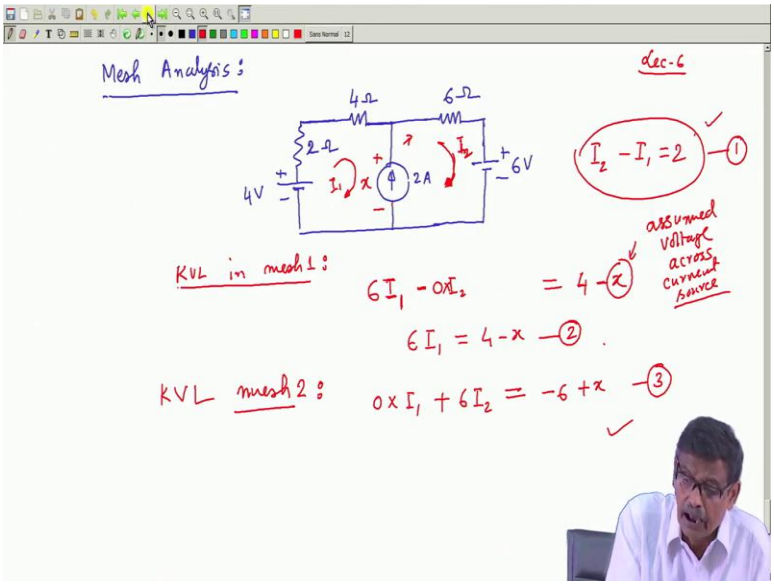

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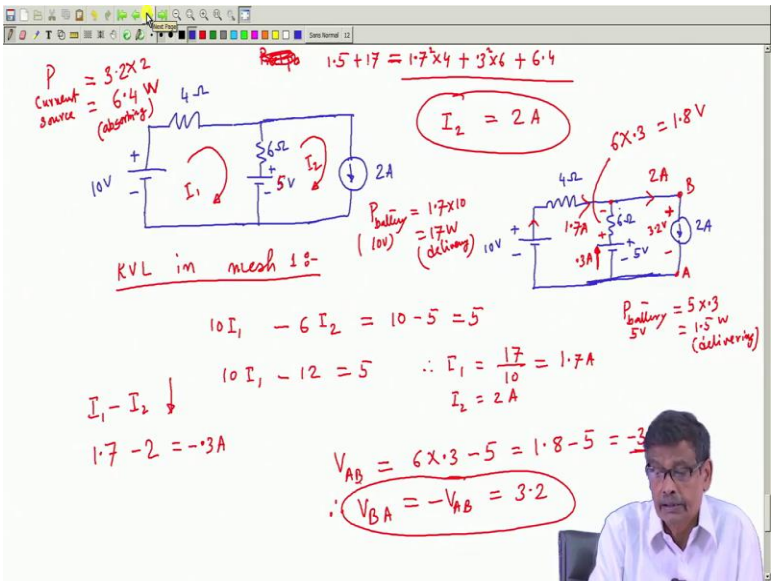

Now, what happens when I consider a circuit like this for example, you have a network like that, suppose this current is 2 ampere and this is there and here is another resistance maybe another battery is present and let us put some numbers to highlight this method because with numbers it becomes easier otherwise lengthy expressions, suppose it is 4 volt it is 6 volt with this polarity is important and this is 2 ampere ideal current source and this is supposed to 2 ohm.

This is suppose 4 ohm this is suppose 6 ohm and have to find out the current in various branches and solve this network. Now and I have decided I will apply Mesh analysis. So, first thing I identify the messes, independent messes are this too early. So, I will assign a current I1 here and I2 there this is I2 to Mesh Karts unfortunately here I cannot say I2 is 2 ampere. 2 ampere in this branch but about 1 thing I am here.

Current in this branch because of these assumptions of this mess current this is true I2 – I1 = 2, this is definitely true has to be, because in this branch current is fixed a current source is present. So, what do I do then, if I want to apply mesh analysis, as I told you that suppose I attend to write down the KVL equation in mesh 1 KVL in mesh 1 it will be as we have learned, the sum of all the voltages in this loop has to be 0.

So, coefficient of I1 will be 6 into I1 is not coefficient of I1. Now, here comes coefficient of I2, there is no resistance here so, it is expected coefficient of I2 will be zero I mean – 0*I2 let me

write that – 0*I2 and on the right hand side I will write about the sources what are the sources for volt is present. So, on the right hand side and deduction of I1 is in consonant with this polarity of these 4 volt, so, +4 volt will come there.

Now, there is that another source which is 2 ampere current source, but as I told you, when the current source is there it is true the current in this brand has to be 2 ampere, but voltage I do not know got the point. So, that becomes an additional unknown therefore, the rule is same 6I1 – 0*I2 is this is equal to and only 2 messes are there is equal to the source terms will appear. So, it is +4 volt it is over.

Now, here you have to then assume this thing I do not know these voltage is x volt because in an ideal current source current is fixed but bolted is decided by what are the things connected across heat, so, many things are connected some voltage will definitely appear across x. So, this can be taken into account by rating like this, but here is the important thing, this is voltage across current source assumed voltage have assumed both.

The polarity and magnitude of the voltage x as I have shown assumed voltage across current source. So, this is the question so, what will be the thing then 6I1 will be equal 4-x. So, it looks like there are now 3 unknowns to mesh current and this x fellow. So, this is in mesh 1 in mesh 2 KVL in mesh 2 will be coefficient of I1 nothing there is no common resistance so 0*I1. Then coefficient of I2 is sum of all the resistances 6 only + 6I2.

That will be there and they should be equal to the sources on the right hand side. Sources should appear that is the logic we develop cardia from the basics so, this must be -6 volt because direction of this I2 and plus or opposite so, -6 and then there is another source whose voltage is not known, but I have assumed it to be x here should I write +6 or -6, +6 because this is the direction of I2 and here is the source. Whose voltage is + and -. So, +6 volt.

So, this equation was equation 1, this equation was equation 2 and this is equation 3 and nothing is to be any double. So, 3 unknowns 3 questions. Therefore, the point I want to stress if a current source appears in the common brand between 2 adjacent messes then the number of equations

are to be solved is not equal to the number of messes, but one more for in this problem mode 3 equations.

This is 1 this is 2 this is 3 is not, but if this current source appears in the outer loop then you really get advantage got the point? In any case, normal thing we say generally in mesh analysis number of equations to be solved is equal to number of places. And in some particular cases when the current sources present in the outer messes in some outer messes of his circuit, then you get some advantage because those mesh currents are known but number of variable increases.

When there will be current sources present in the common branch. As in this simple example, we see I1 I2, they are of course, related by this current so, simple equation I2-I1 has to be 2 and then voltage of this current source is unknown. So, while writing down KVL equations, you follow the single coefficient of I1 some of resistances and so on, coefficient of I2 if there is no resistance in this branch it is 0*I2. But on the right hand side, this X will has to appear.

Do not be under the impression, this voltage is 0. You do not write anything here. It is not short circuit often students make mistake here understood. Therefore, if at all you choose mesh analysis, you should be careful about this points try to take advantage of the fact that current sources in many of the outer loops are present. O immediately go to mesh analysis because outer loop current sources means those mesh currents unknown.

Number of equations will be to be solved these will be less than the number of messes. If current sources appear in the common wall between the 2 adjacent messes, then actually number of equations to be solved becomes more understood, this point must be highlighted. Once again 1 can apply after you have solved as I told you solved it get the values if I1 comes out to be negative.

Then it is a good practice at least when you beginning to learn this course, regard the circuit. So, the actual current direction if I1 becomes negative put it negative see that case KCL really satisfied then you can do power balance of the network as usual. So that I am not doing so, I am

also not solving this network. So, 3 equations 3 unknown except than other nodes, now I will tell you about

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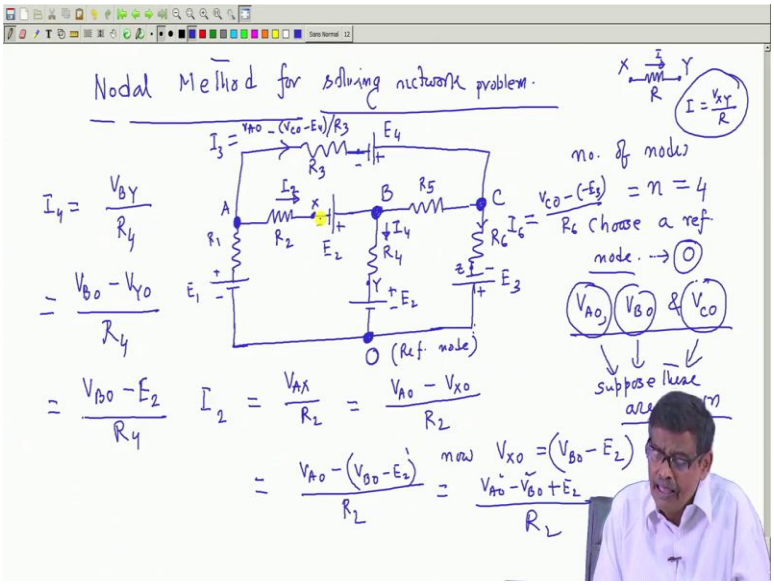

The nodal method that is also very interesting and see, the point is, there are several techniques. If major techniques, then for a given network you try to adopt a method which will reduce your labor to solve the network that is the whole idea efficiently you try to solve that. So nodal method of solving network for solving network problem very good. Now in this problem once again let us take A an example suppose, and first I will write down in terms of variables, I mean symbols E1.

This is R1 this is R2 let there be another voltage source, it does not matter E2 there is voltage a voltage there and there is resistance here and another resistance there and also there is something like here. So, E1 let this be E2 let this be E3 and this is R1 R2 so this be R3 and this be R4 R5 and R6 in nodal analysis what they say is this that first identify how many nodes are there as in case of mesh analysis we identify how many messages are there.

Now, junction between 2 elements in general can be called a node in general. But here what I will tell is this a no disappoint were more than 2 elements inside join. For example, this I will

call it a node got the point. For example, this I am not going to call a node elements of R2. And this element source is A, N has had been joined this I am not going to call. So at least so nodes are these things, at least more than 2 elements ends had been joined.

That I am going to call node. So here you see this, becomes 1 node. 1 to 3 ends of 3 elements have been joined this I am not going to call him node, although it can be called loosely, but this is how and this is another node. And this is another nodes and of course, this becomes another nodes and name the nodes. For example, call it a B C and let us call this to be O the essence of the nodal method for solving electrical circuit centers around this path.

I have told you that given a network the potential between any 2 points, what does it mean and how to calculate that, I know for example, if you have a resistance first, let us try to understand this is R, this is pointing, suppose, not in context with this A B. A general then the current through this if you say from A to B current is flowing, that is what you are assume, then I must right I = potential of A with respect to B divided by R.

The same thing 1 can write that a same R same AB points and if you assume the current to be in this direction he will write x ampere he should write the BA by x R you must understand this point. So, depending upon the direction of the current that is your choice potential of a potential difference across R is VAB. We know that now, if this current in this R gate there is some other point to and if you have calculated VAB can be written as VAO – VBO with respect to same point.

If you know the potential of point A with respect to the same point if you know the potential of point B, then VAB will be nothing but the difference of these 2. Why? Because you see the AO. For example, in this example VAO I know what I mean I have to start from O try to reach point B. So, I start from O suppose I decide I will go by had this path. So, put in shall appoint a can be written as from this to this whatever voltage will be there.

That is also potential difference between these 2 points VBO start from O. VBO he will get that is this draw and this draw we do regard to their + - sign you calculate this we have reached this

point is not VAO = VBO. Then from this to this you have to go and that voltage is what VAB whatever it will be potential of A with respect to B you go. Therefore VAB is always VA0 – VB0 it is an important thing.

That is with respect to but the point of reference should be same for both the ends, so, this you must understand and then I will say that forget about this we have understood this and this point so, that is the thing. So, what is done in nodal method is that first you identify how many nodes are there in this particular problem number of nodes, is equal to which I will denoted by n and in this case.

It is 4 it is that then what we will be doing is this will be and then I say that choose a reference Choose a reference node I have identified the nodes I have chosen a difference node and that reference node I have named it as O at this point you must understand that any of this I could choose as reference not necessarily this 1 got the point I could choose C as my reference. Now, what is a reference node with respect to this node, I will calculate the potential of further nodes.

That is, I am going to find out VAO, VBO and VCO got the point. If you have had chosen C as your reference then we will say I will calculate all the potentials of the circuit with respect to this point BAC, BOC, BBC. So in this case, I have just arbitrarily chosen O as a reference node generally one observation is this people choose that point as a reference node, where many aims of have been joined more than 3, 4, 5 bends are join that part will come to this.

So, I have chosen O as a reference node. Then I know what the, what is the meaning of VAO means potential of A with respect to O, potential of B with respect to O potential of C with respect to O so, this is E1, E2, E3 and E4 now, I make 1 statement that in a network my final thing I have to calculate what will be the currents in various branches. For example in this branch what will be the currents.

Now, as I told you current in a resistance, if you have X and Y as it is 2 terminals, and if you want to find out current in this direction I, then you must write I as potential of X with respect to

Y by R this is crucial. There you do not fumble, this is the thing. Now, I am saying that if by some means, by hook or by crook, if you can somehow know this voltages this 3 voltages somehow you have been able to calculate doing what that to be discuss, but if I say that in this network node that VAO is known.

VBO is known say it is 10 volt VBO is 5 volt VCO is 12 volt. Suppose I say that, then I will say the calculation of branch currents will be just very simple now, why suppose, these are known, these are known, then I am saying that all the branch currents can be calculated using those 3 information alone how let us see for example, to calculate the current in this branch say I say I want to calculate this current this branch.

Although this is not named let me given him X this point let me call next, then what is this current I2 say this branch current I2 will be VAX potential of A with respect to X divided by R2 grab the resistance in that branch find out voltage across that resistance divided by R2 and no one can contest me this is absolutely correct. Now, this VAX this is the crucial step. I will write it as VA0 – VX0 divided by R2, this will be this current title.

Now then I will say that look here VX0. Now, this point is crucial VX0, potential of X with respect to O because these are the things I know VA0 VB0 VC0 somehow I know so VX0 will be how much you know VB0 that means, you have already reached point B, then point B you cry to go to X. So, what it will be it will VB0 then + to - so –E2 that will be the thing VX0 therefore, you see I2 then becomes I2.

VA0 then – VX0 is nothing but this quantity – VB0 – E2 it is not and that divided by R2 it will be = VA0 – VB0 - + E2 divided by R2 this will be the current. So, can I not calculate I2 because I have told you that VA0 VB0 VC0 I am supplying you the values I2 can be expressed in terms of that it is after all a constant EMF value. So, these things are known I2 can be calculated take this current these branch currents say this current is I4 grab the resistance R4.

So I for, will be equal to, at this point no name is given. Let us call it Y. So to be consistent to this, expression here, I can write I4 will be nothing but VBY potential of B with respect to Y

divided by R4 this will be the current. Then what do I do VBY can be written as VB0 – VY0 with respect to same point divided by R4 this will be the current. Now, the big question is what is VY0 from 0 you try to go to Y it is +E2 to nothing else. So, this = VB0 – E2 divided by R4 I4 can be calculated.

Because VA0, VB0, VC0 are known very simple. Similarly, I6 can be calculated one can go on adding and I am now telling it will be simply you try on your own it will be VC0 and from these to these minus potential of this point if you call it Z, BZ0 is – C3 + to – so, - C3 divided by R6 and so on similarly this branch current I am very quickly writing it will be this branch current say I3 if I say I3, it will be called to VA0. Will be there - potential of this point with respect to this.

And that can be translated into BC0 – E4 and divided by R3 is not. So, in fact for a new branch you can do it therefore, first the point to be noted these days, identify the number of nodes and I just told you today that E this node voltage is unknown with respect to a difference node voltages say here n equal to 4. So, 3 node voltages 1 of them you will choose as reference and there is no condition that O is to be chosen as a reference.

Any 1 of them can be chosen as a reference I have chosen O. So, the other 3 node voltages with respect to that reference node. If these potentials are known, I am telling you, you have almost solved the socket. Because the branch currents, any branch current in this type of network can be expressed in terms of those node voltages. As example I4 is VB0. And so on I2 is this one VA0 VB0 + E2 by R2.

Therefore calculations what is the essence of the thing in any branch grab the resistance. Whatever is present and apply this route these the fundamental ohms law voltage across this resistance is the current VX by R2 is current from left to right. And VAX can be written as VA0 – VX0 so, from O right to the reach X and you will find that can be expressed in terms of other node voltages and some sources present. Anyway we will continue with this in the next class. Thank you.