Network Analysis
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Lecture – 70
Circuit Analysis with Dependent Sources - III

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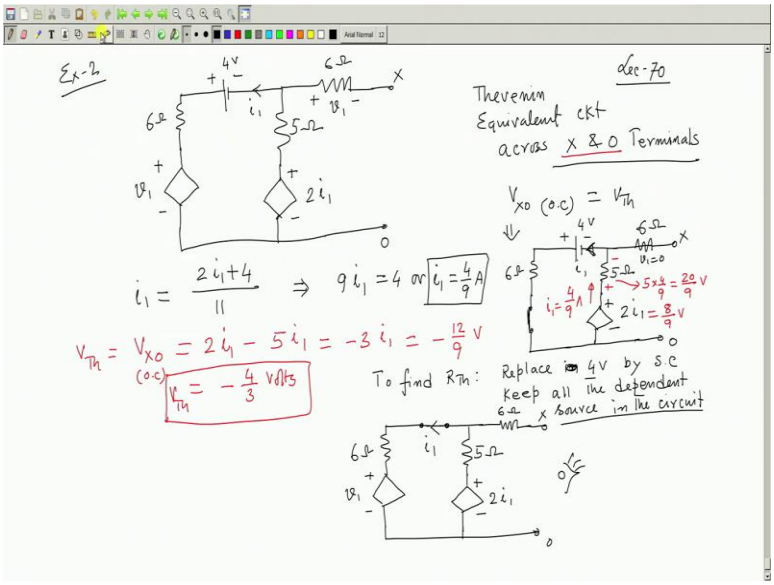

Welcome to Lecture number 70 on network analysis, and we have been discussing how to solve network problems which are having both dependent and independent sources. And it is always better to explain the ideas in the form of some problem solutions. That is the better way to do it because we know ultimately KVL, KCL somehow we have to write down in the equations.
So, in my last class I took a very simple Network and explain how to find out currents in the networks having both dependent and independent source.

I will take another example, to example 2, in continuation with first lecture. And this network is also simple but, let us do this exercise. Suppose you have a network which is I am drawing now and there is a dependent voltage source present in this branch, which is written as B1 what is B1 it will soon come that is it depends on some voltage V1 elsewhere in the network. So this is a independent source 4 volt and here is a 5 ohm resistance.

There is another dependent voltage source plus minus 2i1and this i1 is this one. Whenever your one ampere flows this way it will be a 2i1 volt source coming into the network. And finally here we have a 6 ohm resistance. And these are the 2 points where I would like to connect some load and find out the current from there. And this voltage is given with this volt. That is whenever there will be a voltage across the 6 ohm resistance, in this branch, voltage with this polarity. This is plus this side will be also plus. It will appear in this network.

And suppose you connect it in ohm resistance here; find out the current in the 10 Ohm. So I was telling you that you find out the Thevenin equivalent of this network, of course without finding techniques Thevenin equivalent. You can find the current in any branch you like with these 2 terminals connected with some impedance. That is always there. But let us try to find out the Thevenin Equivalent circuit across X and Y term or terminals I want to find out.

So, to find out Thevenin's equivalent circuit what you have to do is this. First you have to calculate the open circuit voltage? That is VXO with open circuit, nothing is connected across Vxo that is the Thevenin's circuit let us first do that. So if you do that nothing is connected. Therefore, no current will be flowing in this network in this branch 6O. Therefore, voltage across 6O will be 0. If that be the case, then, to calculate Vth Thevenin's this current being 0 no voltage drop across 6 ohm.

This network will then look like 6 ohm here and between these 2 points it should be then shorted because V1 is 0 and there is a 4 volt source. It is independent source. It will remain 4 volt. V1 is 0. And this is 0 means 0 voltage between these 2 points and here it is some 5 ohms. Here, of course, the currents will be there. So to find out Bth Thevenin’s, all the sources should be present. And I have taken all the sources. Here 6 Ohm resistance is also there.

Of course, there is no current here. There will be 0. V1 is equal to 0 that is why this one is shorted. But you should understand. So and this is to 2i1 is this current. V1 is 0 no. There is a closed part here. Some current will flow and this current is 2i1 and I have to find out the potential difference between these 2 points. How do I find out Vxo. I will start from O and try to

reach X via any path highlight and whatever number will come that will be the Thevenin’s voltage of this network.

So while calculating Thevenin's voltage, you should keep all the sources in the network dependent and independent sources. That is what you should understand. Now it is simply a series circuit here in this group. There is no current. There is open circuit. Therefore, current will be in this loop only and the magnitude of the current i1 we can easily write it down as voltage acting in the network in this direction. That is 2i1 + 4 volt 2i1 + 4 volt divided by 11 because total resistances series circuit +4 volt divided by 5 + 6 11.

So, this means that 9i1 you bring it 11i1 minus 2i1 is equal to 4 or I will say i1 is equal to 4 by 9 and there will be equal to 4 by 9 ampere. This is the thing. And if I know i1 is 4/9 ampere, current in this branch is known. 4/ 9 Ampere Current in this branch is also 4/9. Therefore, Vxo, so and therefore there will be a voltage drop across the 5, ohm resistance whose value will be 5 into 4 by 9 that is equal to 20by 9 volts. Therefore, and this voltage source magnitude also, I know.

That is 2i1 that is 8 by 9 volt because i1 is known. So, Open circuit is your Bth Thevenin’s between point X and O start your journey from o. So there is a voltage rise of 8 by 9 volt. That is I first write it like this 2i1, then minus 5 by 1 -5i1. Then, from this to this no drop. So this will be then equal to minus 3 into i1 which is equal to minus 12 by 9 volts which is equal to -4 by 3 volts. So, this is the Vth Thevenin’s. I have found out now.

Now, I have to calculate Rth Thevenin’s means, I want to express this network as a Thevenin’s equivalent factor of 6 and O. So I have to calculate the Rth Thevenin’s. So to calculate the Rth Thevenin’s is what you should do is this once again, please this you put it in your head that while finding out the Rth thevenin’s dependent sources should be in the circuit. And it is the independent sources which should be replaced by their internal impedance, that is to find out Thevenin’s resistance.

What I should do, ah let me draw here enough space is there so first 2 to find out? To find Rth Thevenin, replace independent sources only one independence of 4 volt, replace 4 volt by short circuit and keep all the dependent source in the circuit, keep all the dependent source, source in the circuit, that is what first thing to do. OK. So, the network then will then look like 6 ohms dependent source I should not play with let it be in the circuit.

Here many students make mistake resources should be replaced by their internal sources, no, if it is dependent do not replace them V1. Then, this 4 volts shows I will start it. Yeah this one and this one is 5 ohms. And this one is another dependent source. It should be present in the circuit and this current if it is i1 it is voltage that is what is given in the problem 2i1 and then there is a 6 ohm resistance and I have to calculate the Rth Thevenin's looking from Exo of this network. ok

So, 6 ohms 5 ohms is shorted that was the independent source. So this one will profit for the I like this. So this is the thing I require, I will copy. And go to next page. And paste it.

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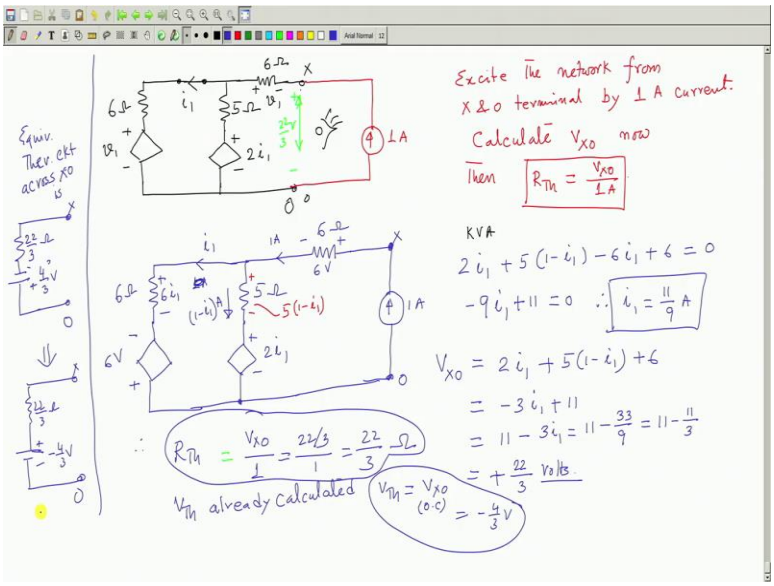

So this is the to find out the Thevenin's theorem we have this network. What was the value of this 6 Ohm, so that was the 6 ohms. Now, here, once again in case, when a circuit has only independent sources, we will be replacing those independent sources by that internal impedance is so there will be only impedance is present in the network. And therefore Rth Thevenin's can

be found out by series parallel combination of the impedance, impedance equivalent we have to find out or by using star delta transformation.

But here it is not like that. I am not sure whether 5 ohms or 6 ohms are in parallel. No, they are not. So, by series parallel formula or star delta transformation it is not going to help you. So there are 2 ways of doing it. Always you excite these 2 points X and O and mind you this is V1 that is what it is given. I will excite these 2 points with known source, may be a voltage source, current source. So, I will excite this network with suppose an one ampere current source like this.

To find out Thevenin's theorem, so, this current drawn by the circuit 1 ampere and excite this network, excite this network so that from x and O terminals by 1 ampere current or that would be 10 ampere current source also. That you decide. What you will do one ampere current source. I am just so that you can do whatever you like. With this circuit excited by 1 ampere current source calculate Vxo, so, now Vxo, now, which is not open circuit now, I have to calculate the potential difference between these two.

Then, if I know Vxo, I will say Rth Thevenin's will be Vxo divided by this one ampere voltage by current. Will be voltage applied to the network whatever you get, because across the current source voltage is not known, you have to calculate the other way round. So, so, this is, this will be these steps. Essentially, I have to calculate Vxo, voltage between these 2 points when it is excited by 1 ampere current source clear.

No. if you are exciting this with one ampere current source, the voltage drop across 6 ohm resistance is 6 volt with this plus this minus. Then this network will look like with the different colour I will draw. 6 ohms this voltage dependent voltage source and this is shorted because independent source I am calculating Rth Thevenin's. This is this is i1and this is 2i1, that is fine, this resistance 6 Ohm since we have forced a one ampere current to flow through it.

The voltage will be 6 volt 6 into 1 with this polarity there. That is equal to same V1 so this voltage will be also 6 volt. This polarity you must understand. Or alternatively you can write + - - 6 volt. That is I hope you know by this time. What all these means by now. So, this is the

circuit. Now, 1 ampere what is my goal? My goal is to find out the voltage across this current source that is the thing I have to do now. ok

And this current I am telling it is one ampere. No, this is i1 and this current is already known to be one ampere. Therefore I can say the current in this branch in this direction should be 1 - i1 ampere. 1 ampere i1 goes so 1 - i1 must be flowing in this direction. Then, what will do? We will write down the KVL equation in this loop in this group. I will write down the KVL equation. So, if it is 1 minus i1 flowing in this direction, then, the voltage across this 5, ohm resistance. Let me write in ray, this will be 5 into 1 minus one.

This will be the voltage across this resistance with this polarity because 1 and -1 is downward. Then write KVL in the slope, start from this point. And let us try to write down KVL. KVL, I am not having the loops I am identifying, identify the loop in this way. So you understand. So, it will be then 2i1, start your journey from this point, from this to this minus to plus. Then, from this to this also - 2 + so write plus 5 into 1 - 1, you reach this point.

And from this to this voltage drop here will be i1 flowing like this 6i1 plus to minus, so that must be -1. It is like this. Then once again - 2 + and that is 6 volt +6v. We do not write everything is in volt so that is 6 volt and that must be equal and you have reached this point. So this must be equal to 0. That is so what you have got is 2i1 -5i1 and – 3i1 and – 6i1. So, it will make it – 9i1 and what are the constants here? Constant will be + 5 + 6 + 11 and that is equal to 0.

Therefore i1 is equal to 11 by 9 ampere. Once I know i1, I will be able to calculate Vxo. Mind you this is, so, therefore I will say, Vxo, in this network, potential difference between this to start your journey from o and try to reach X by this path. So, Vxo will be 2i1-2 Plus. Then, plus this voltage plus 5 into 1 – 5i1 and from this to this, it is a voltage raise of + 6 volt. 6 volt and you have reached point X. That is what Vxo. There is no voltage, it is the voltage existing current.

So, so, so this one will be 2i1 and -5i1 means minus 3i1. It will be and + 5 + 6 that is plus 11. And so, it will be 11 - 3 into i1 which is equal to 11 - 33 by 9 because i1 is 11 by 9. Is it correct? So, so this will be actually 11 by 11 by 3 and if you calculate it will be 22, +22 by 11.22 by 3, so

this will be 22 by 3 volts. See, once you have got this Vxo, I will tell Rth Thevenin's, whoever is looking into it is voltage now, I have calculated. Let me use different colour this voltage.

This voltage, X + and this is minus this voltage now I have solved. This voltage is 22 by 3 volts. So I will say this network is drawing 1 ampere current? When 22 by 3 volt voltage is applied between X and o, therefore, what should be Rth Thevenin's? Rth Thevenin's should be then Vxo by 1 ampere. Vxo, I have now calculated so 22 by 3 by 1 is equal to 22/ 3 Ohm, that is all. So, this is the Rth Thevenin's and its value.

Therefore, in the previous thing, we have calculated Bth Thevenin's which is equal to minus 4 by 3 volt and now Rth Thevenin's is known so Bth Thevenin's is already calculated already calculated to be open circuit equal to how much -4 by 3 volts. -4/3 so this together with this, I will be able to draw the equivalent Thevenin's across point XO. So therefore equivalent Thevenin's circuit across Xo is how much?

Bth Thevenin's is minus 4 by 3 2 ways you can write Rth Thevenin's. Rth Thevenin's 22/3 ohms and Bth Thevenin is minus 4 by 3 volt so it should be shown like this. And this is your point x and this is your point O whatever impedance you know connector will be able to calculate. Alternatively what you can do is this 22 ohm? 22 by 3 ohm resistance does not cause any problem. Bth Thevenin's with this polarity you want is only right. But, while writing this magnitude, you must write this as -4/3 volt.

Then this is X, ah they are one and the same thing. This 2 you must understand because potential of X with respect to oh, I have got to be - 4 by 3 and so on. This is the one way of solving the network. Now, what I will be doing so you got the idea. The point to be remembered it is while calculating Rth Thevenin is, see you should not remove the dependent sources. Only independent sources should be replaced by the internal impedance and excite the network through the points where you want to find out with any known source maybe a current source maybe a voltage source.

It does not matter but do that and then replace the dependent sources by their internal impedances and solve this network. So if you have excited it with a current source, you must know what is Vxo now to say what will be taken in simple impedance looking into this. Another way I told you that you have already calculated Bth Thevenin's. You have got it. That is what I will also do for this network.

Open circuit voltage you calculate. Then what you do you calculate the short circuit current? that whatever will be flowing. So, this another way of doing it is to calculate calculate the short circuit current if x and o are short circuited, if I can calculate that current then this open circuit voltage divided by this short circuit current which am going to find out will also give you Rth Thevenin's. It is a good practice to do that.

It will then make your understanding much better that in any case; you must come out with a unique value of Thevenin's voltage and Thevenin's distance. So, what you do is, this you will copy this network for now, I have already calculated. So I copied this. And go to next page. And paste it.

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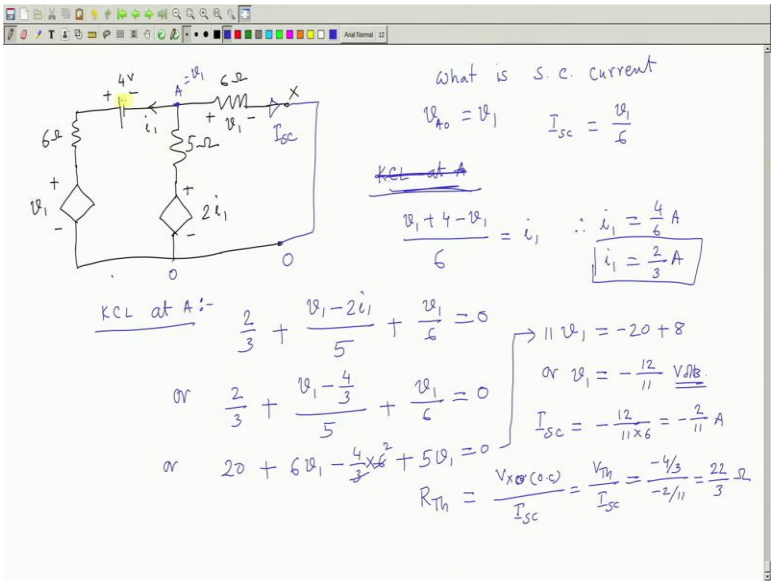

That is suppose I ask you. This point is over, adding all parameter values as the original network asking you. What is short circuit current? Short circuit current when x and o are short circuited, this current ISC. This is how much I want to find out. Got the point? This is the short circuit

current I want to find out for the same network. And these the complete network. So I have to solve this network. And get the value of the short circuit current. So what do I do?

You note that this point is x this point is A this point is o. Now, voltage across x o because we have short circuit, X is equal to 0. First thing you note that Vao to be equal to V1 itself because this point is now same as this point. So, so the potential of this node with respect to this point is nothing but V1 itself, clear. Therefore we can say that ISC, this current is nothing but V1 by 6 V1 divided by 6 is this current. This is one equation.

What are the unknowns in this case ISC V1 and i1. These 2 are there by this simple i1. Now if that were the case then what you do, is this, you write down the KCl at node A or 6i1 + 4 Ok so so V1 is equal to VAo what you do is write down KCL at node A. What will be this is V1 so we 1 + 4 - 1 by 6 and do not while finding out short circuit do not keep all the sources present. I am not going to find out Rth Thevenin's. I find out Rth Thevenin's in a different way that is what I am showing.

So, so it will be V1, VAo is nothing but V1 itself. So, V1 + 4 + 4 then once again - V1 divided by 6 is this correct? And this current I am telling this is equal to i1 for, for example. This is not KCL this is true know, in this branch this current is like this. Therefore I see o, i1 is state I have known i1 is equal to then 4 by 6 ampere that is equal to 2 by 3 ampere, i1 immediately can be found out. So, now I know i1 is also known.

For this I did not apply KCL. Just this branch current in terms of the voltage across this branch, acting is how much V1 + 4 - 11 so, i1 is known ok? Then you apply KCL at A. KCL at a it will be equal to current in this branch and that is already known 2/3. KCL current in this branch this will be Plus V1 in this branch V 1 – 2i1 by 5 is this current? and this current is given V1 by 6 and that must be equal to 0. Because this was shorted so the voltage is V1, is it not?

So, but, i1 is known i1 is that 2 by 3 ampere so we write 2 by 3 + V1 -2i1 that is 4 by 3/5 Plus V1 by 6 is equal to 0. V1 is to be calculated to find out ISC because ISC is V1 by 6 so we are almost at the end of the problem. So that is the thing. So what best you can do to solve the circuit

multiply with 30? Therefore if you multiply with 30 it will be 20. And + this will be 6V1 minus 4 by 3 to 6 terms and + 1 + 5V1 and that is equal to 0.

So, you get from this that 11 V1 will be equal to -20, 20 you bring it to this side and this is +8. Or V1 is equal to -12 by 11 volts. This will be V1, is it correct? Then ISC short circuit current is V1 by 6 - 12 by 11 divided by 6 is equal to -2 by 11 ampere, ISC will come. ISC is this much? When I am telling Rth Thevenin's should be Vxo, open circuit condition that is Terminal voltage divided by ISC. That is Vth Thevenin's divided by ISC. And Bth Thevenin's how much we got – 4/3 volts.

So, you put those numbers so minus 4 by 3 divided by minus 2 by 11. And this one again will become equal to 22 by 3. 3 So, in whichever way you do it, but do it correctly what I am telling because the dependence sources are present, this is the challenge. You should be very careful while you, one way of finding currents in any branch of the circuit do not go to Thevenin's theorem. You just solve the network as it is.

For example in this network, we find out find out all the currents I have never calculated anything all the branch current can be calculated by simply writing KVL. Hope you understood this some more problems with dependent current and voltage source, I will try to upload and please go through them and also you solve problems from books whatever is available with dependent source not too complicated circuit, but at least simple circuits.

You do it will give you confidence. Hope you have understood the basic idea how to handle networks having both dependent and independent source. In my next class I will start new topics, that is, 2 port networks. Thank you.