Network Analysis
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Lecture – 69
Circuit Analysis with Dependent Sources - II

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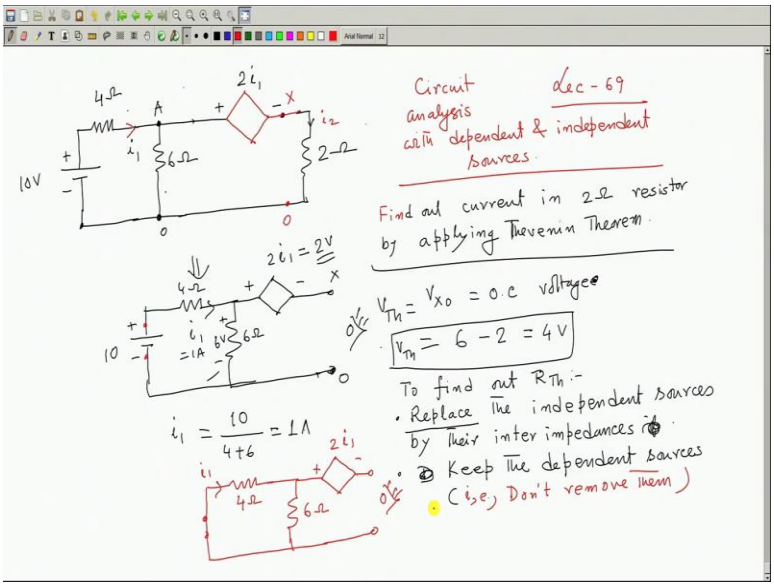

We have been discussing about circuit analysis, when both dependent and independent sources are present and we have considered a very simple network, this network in the previously lecture and found out the currents. In various branches, for example, this current also you found out, you know i2. So, suppose to ohm is this assistance and you can apply any method you like I told you. Now one important and what is this dependent source I am telling?

It is will be represented by Diamond shaped lock like this and the polarity of the voltage will be shown and it is telling me that whenever in this branch 4 ohm resistance, I want flows from left to right then there appears a voltage source share. And we got the value of i2, i1. Now, one important thing, I would like to tell. Suppose this I call so, and this point I call point x. So, this point is o because xo and 2o is connected.

If I reframe the problem as telling that find out, find out current in ohm resistor 2, ohm resistor by applying Trevenin's theorem, Trevenin. Suppose I take. So, what is the fastest first step is?

First step is as we have done in Network analysis with dependent sources alone you first remove this 2 ohm resistance. So, so, remove this 2, ohm resistance and the circuit will look like this now. This is this is 4 ohm, this is 6 ohm. So, first open remove this 2 ohm this is this circuit?

And these are the things given 10 volt. So what I have to find out is B7 is voltage from this. B7 is open circuit voltage existing between Terminal X and O. So, Vxo is the open circuit voltage? existing between X and O. so, this circuit is opened and so to find out Vxo we have to start from O and try to reach X by any part i like for example I have decided I will go by this part. Now one thing is clear since it is open circuited, there is no current here ok.

So, whatever current flows here and how much is this current i1 value will be 10 divided by 4 + 6 is equal to 1 ampere? This is equal to 1 ampere straight. If it is one ampere then, this voltage 2 into a one which is one ampere from left to right this too. I want will then become 2 volt. And this current is one ampere. What is the current here? And this current is one ampere therefore, what will be the voltage drop here plus minus? 1 ampere is plus 6 volt 6 volt.

Therefore, v ohm is equal to Vxo open circuit voltage. So, start from O and try to reach X so it will be 6 + 6 then -2 that is equal to 4 volt. Is it not? That voltage source to calculate Vth voltage open circuit that keeps all the sources both Independent and dependent sources present in the circuit. And calculate Vxo which comes out to be V Trevenin's equal to 4 voltage? Is it not? So, this is Vth. And it has come out to be Plus.

Then next stage is to calculate the Rth value. Now to calculate Rth value, looking from this side, what you have to do is this generally when we did not know about the dependent sources the states are that you replace all the sources by their internal impedances. If it is ideal, they should be shorted if it is a voltage source. If it is a current source, it should be open circuited. We know that but in case of both the dependent and independent sources present to find out, to find out Rth means across x and o, replace this point is important to replace independent sources by their internal impedance, Impedances if any.

Internal Impedance for ideal voltage source should be zero shortage, Ideal current source it should be open circuited. And the finite value of internal impedance is the present I will show those values in the circuit. Here is a 10 volt independent source to find out Trevenin's volt what I have to do is this I have to redraw the circuit replacing the independent sources. The next point is do not, do not can keep the dependent sources do not remove that.

Dependent sources that is, that is do not remove them from the circuit do not remove that. So if I do that, then the circuit will look like, this will be shorted. This will be 4 ohm resistance. This is also 6 ohm these two points are also shorted internal resistance is zero ideal battery shorted. This is 6 ohm and this I will not remove them I will keep it here. And this relationship is this this is I want this is i1.

And this is 2i1 and I will try to find out the impedance looking from this end. That is what I have to do. Now, how will I find out the equivalent resistance when independent, dependent sources are present Ok? 4, 6 are parallel but what to do with 2i1 one business. Of course, i1 is 0. In this circuit if we replace it by a short circuit, with this open circuit no current exist. So i1 is 0 current. If i1 is zero, there is a voltage which is 2 into 0 that is zero that is shorted.

So I am telling, I am just doing like this, that if it is 4,6, so it is 0 then is it equal to 24 by 10? 2.4 no, is it not? To find out in such a situation the Rth what you do? You connect a known source between these points exactly and try to solve the circuit. So what are you doing this I will better I will redraw in the next page. So, copy this. So, this is the network.

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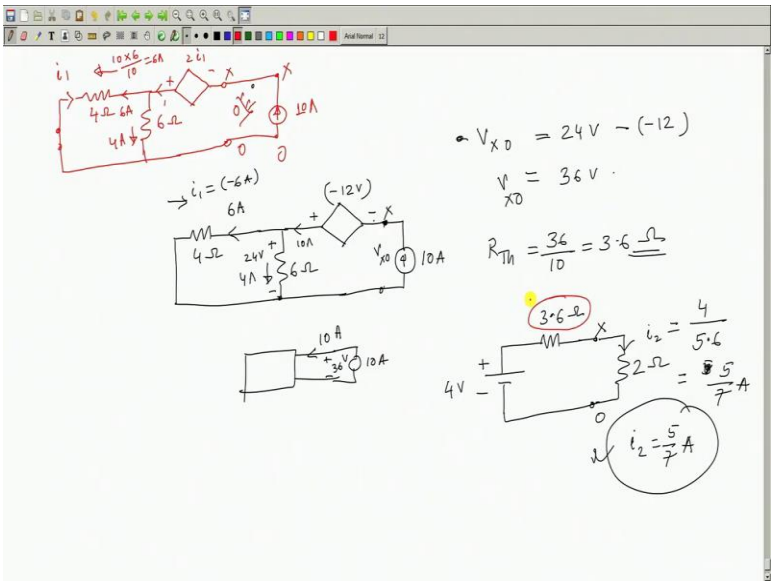

So, we go to next page and paste it. So this is the network. I want to find out the Rth. Now, how to do it that is what I was discussing? Xy is open circuit and I have to measure the resistance offered by the sole network to you. So, what you do you connect an external source share sorry. So you connect an external any source either voltage or current source, for example you decide that you will connect a current source for voltage source or current source.

Suppose you connect one ampere current source. I will connect and then I will try to measure what is the voltage of this network between this two points and o? Then voltage by current will be the impedance of this network between point X and O, that is the whole idea. So, I have connected a current source, clear. The moment you connect the current source between these two points, 1 ampere is flowing here. Or connect 10 ampere it will be easier.

Any current source may be 0.5 ampere will also do. But that you decide. So, once you do that what will be the current in this so current let me this remove? Ok, let me keep this, this is i1 then only this will be 2i1. This is not. But this 10 ampere will come here and it is getting divided into parallel resistance so current in this direction in this branch because of this 10 ampere it will be 10 into 6 divided by 10 that is 6 ampere. 6 ampere will flow there.

And if this is 6 ampere you can easily verify this is 4 ampere. But arrow is important. This is the actual current flowing in the archive. Now here, it tells me that if you know this branch current

from left to right then this voltage will be 2 into i1 with this polarity, therefore the circuit, I will redraw and you should be careful while you are doing this. So, this is forum. This active source is shorted. This is 6 ohm. Now, here, is a voltage source.

With this is plus this is minus and here I have connected a current source. Of any value, 10 ampere I have chosen, so that I mentally know, the equations will be simpler. Forum 6 ohm then what I am telling in this network it was 10 ampere then it is easy to see that this current will be 6 ampere and this current will be 4 ampere. I have to calculate the voltage Vxo, this point is x. Now how to calculate this voltage, I have to start from any point, try to reach here and see the voltage drop et cetera.

And what is the voltage drop between these two points 2i1 with this quality and what is i1, from left to right? So, left to right i1 is equal to i1 -6 amperes that you must take into account. Then you write here, it is equal to -12 volt, is it not? This is this. So, what will be the voltage between these two points this plus this minus? This is 24 volt you know, minus plus 4 ampere. Therefore, Vxo will be equal to start from this point + 24 volt 24 volt then - + 2 - - 12 volt.

And this will be Vxo which will be equal to 36 volt. So, if Vxo is 36 volt and this network is taking 10 ampere current, therefore Rth network, so this whole network across Vxo is now behaving like this. Here, the current is 10 ampere this network is 10 ampere current and the voltage between these two points is 36 volt. That is what I found out. This is the whole network Rth time will be how much.

This is divided by 10, 3.6 ohm. Therefore you see to calculate the Rth you should be careful. Not to replace the dependent sources. Dependent sources let it be there like this and you apply either a known voltage source or current source, it does not matter, we have discussed earlier. And then find out the voltage between these two points and current drawn by the division of these two will give you Rth. Clear.

Between the point X and Y we have found out earlier, the value of Vth item is to be 4 volt + 4 volt, it came. So, this whole network will be then 4 volt and an impedance of 3.6 ohm and then

your terminal x and o as the question was when I terminate this two points by 2 Ohm resistance is it? 2 ohms, what will be the current, in this, this current. That is that was denoted by ith earlier through these 2 Ohms resistance is 4 / 5.6 , so how much it came? 5/7, no it is coming same know.

So 5/7 ampere which is same as the result to obtain i2, in the previous lecture we got this current i2 20/7.

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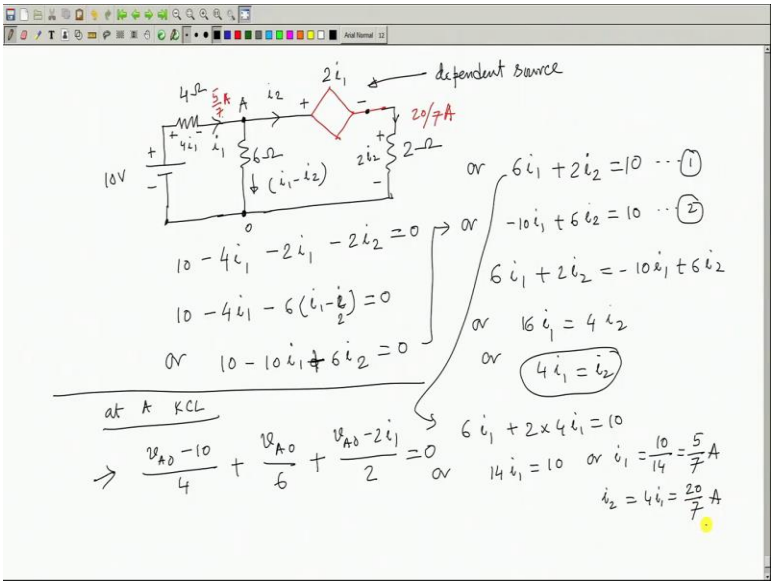

i2 is this one, i2 or i1? i1 is 5/7 i2 is 20/7. This current i2 was how much? So I have replaced this by 4 volt. Trevenin's voltage will be 4, voltage correct? And then Trevenin's resistance is ok 3.6 Trevenin's voltage it is 5/7 ampere then let us check this earlier method here, it was how much so we have got it equal to 5 by 7 and let us verify what we got by the general method without having Thevenin's Theorem.

Ah, we got i2 to be? 20/ 7 ampere which should be 5 by 7 so something must have gone wrong you try to understand. You see there. I made a mistake in this line, while at this equation while 10 - 10 is 62 that is equation 2.

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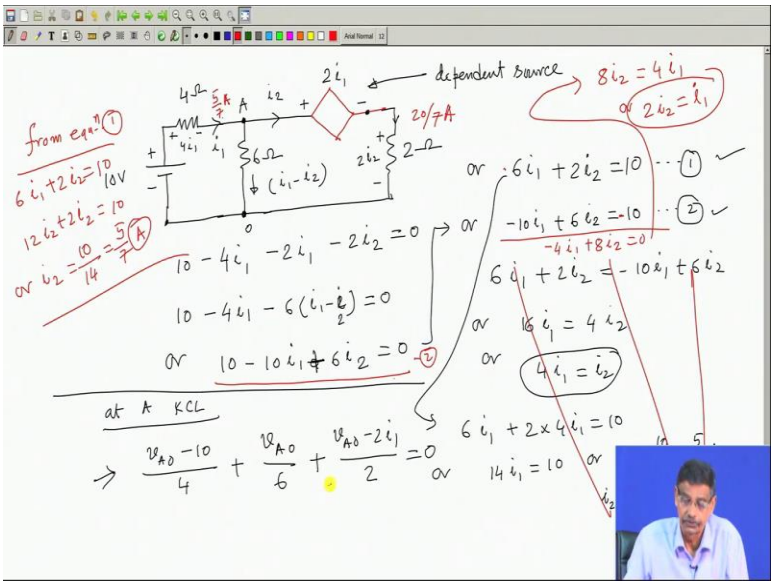

Here I made a mistake which was equal to minus 10 i2 + 6 i2 and line goes to this. It should be minus that is the thing. So let us then correct it at least so these are wrong. So this is -10. Should we please correct that some of you have already noted that so if you simply add this 2 equations here you know, you will be getting now – 4i1 + 8i2 is equal to zero. If you add this 2 and this will be equal to 8i2 is equal to 4 i1 or 2i2 is equal to i1. This is the thing forget about this. So, so I i1 is equal to 4i.

First equation is correct these two equations. So, put in the first equation. so, now in the first equation if you put i1 equal to 2 i2. So, so from equation 1, equation 1, from equation 1 you get 6i1, did this 2i2 is equal to 10 + 10 and i1 is equal to 2 i2, so it will be 12 i2 + 2 i2 is equal to 10 or i2 is equal to 10 by 14 which is equal to 5 by 7 and that is fine. So, some mistake was there I think you have understood.

No matter, whether you are applying Thevenin's Theorem or General method result should come same. So this is the way we have found out the equivalent of the network understood. So, i2 is equal to 5 by 7 ampere and Rth element is equal to 3.6. So, important point is that one. So another way people try to find out the Rth elements.

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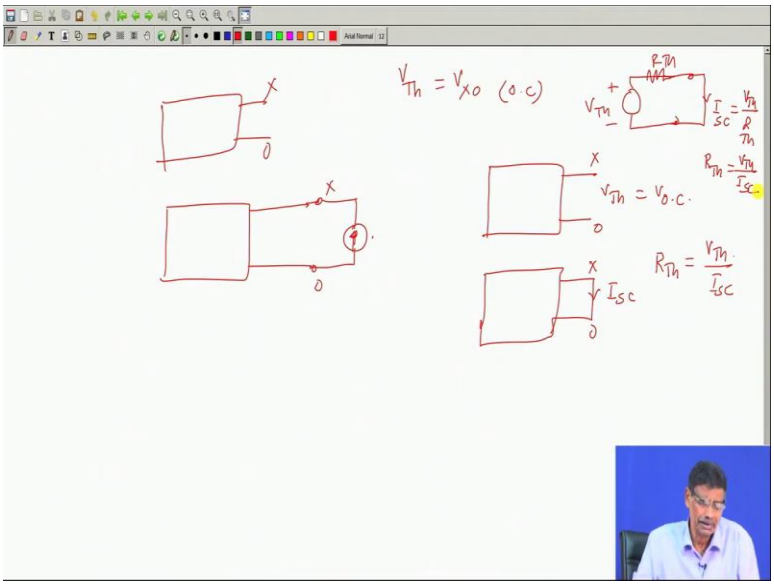

That is if a network is given how to find out Rth elements, network is given. Between two points X and O there may be dependent and independent sources. Now, we know that. Now, open circuit voltage open this to get Vxo, is equal to open circuit. Condition is fine to calculate Rth element is what you have to do? You replace the dependent and independent sources by their internal impedance is keep the dependent sources present and Exide this 2points x and o with known source.

It maybe a current source, maybe a voltage source, whatever it is. If you exide it into a current source try to find out what is Vxo. Then Vxo by this current will give you the Rth element. Another way of finding out with the ones you know that. It is true that for any type of network that you find out the Vth Thevenin's value, that is our open circuit voltage and also find out the short circuit current here. Open circuit voltage you find out between X and O and you calculate the short circuit current when you short circuit this.

In both the cases keep all the sources to be present, dependant, independent whatever it is. Rth Thevenin's is you know will be Vth Thevenin's by Is. So, open circuit voltage another way of calculating simple Rth Thevenin's is to find out the open circuit voltage and find out the short circuit current because va this circuit if it is replaced by we Vth Thevenin's we know that. This is our open circuit voltage and this is our Rth Thevenin's, what will be this current?

When this 2 Terminals are shorted ISC is nothing but Vth Thevenin's by Rth Thevenin's elements. So, Rth Thevenin's element is the open circuit voltage divided by short circuit current so Rth Thevenin's. It is given by Vth Thevenin's by ISC. So, depending upon convenience, if you can foresee that this method if I adopt, result will come quickly, can go ahead of that method. So, by any method you can do it. Ok for example, whatever time is left let me do only that part.

But that is suppose I want to calculate Rth Thevenin's is, Open circuit voltage already calculated. So, I will short circuit accent and calculate the short circuit current of this network. Got the point? So, so, this let me copy. Please, let me copy this. And go to next page. Next page and paste it.

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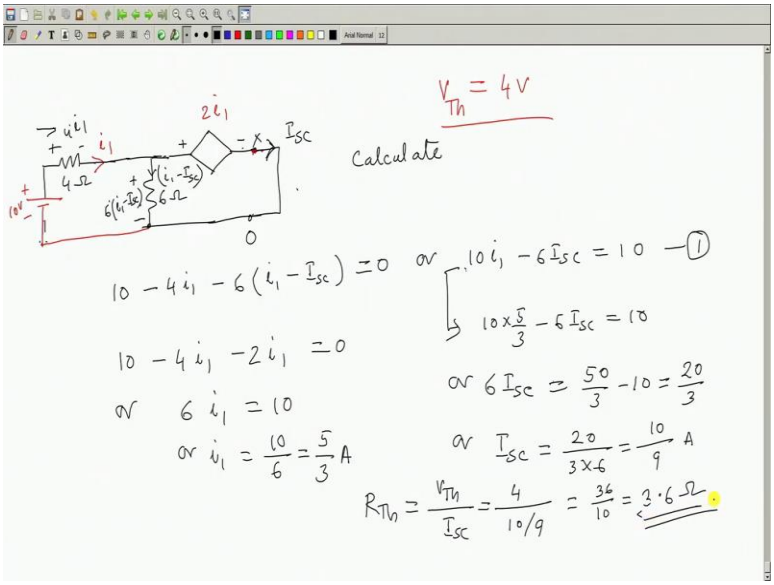

So this is this was the original network. This you will erase, this also. So, it was some voltage source here 10, volt so, this was the circuit. This is independent source 10, volt and this is the thing it was connected and it was given that keep this current is i1, if left to right, this is 2i1. That is this thing now how much you have got already calculated. 4 volt 4 volt Vth Thevenin's is 4 volts.

Now I will calculate Rth Thevenin's in this way. Ok in this network, in this network I will calculate what will be the short circuit current? If you short circuit this calculate, this current ISC

short circuit current and do not remove any sources present source of circuit current let us calculate. And this short circuit current can be calculated easily, remove all these values, these values are not, so this is, this is the situation. I have to solve network with X and O shorted.

Once again, it is the circuit is to be solved. So generate two equations and try to solve the current obviously, if this is ISC, this current here in this branch. It will be i1 – ISC. Apply KCL then the voltage drop between these two points is 6 into i1 minus ISC. So apply here the KVL equation in the slope and please do it correctly. I may make mistake. Point that out. This is 4i1 and that is what I have assumed.

So this minus 4i1, -4i1 and then this is minus 6 into i1 minus ISC and that is equal to zero.So how many unknowns are there to i1 and ISC. This is one equation and this if you simplify, it will be 10i1, this -10i1, I will take it to that side and this is plus 6 ISC take it to the other side. It will be 6 ISC and on this side what things will remain is 10. – 4i1- 6i1 - 10i1 - 6 ISC + 6 ISC this side and -6 ISC I 10 I can keep there. So, this is equation. You have to peacefully do this. This is the in this Loop, the KVL equation in this loop.

Similarly, you apply KVL equation in the outer loop or in this loop, independent loop. So, from this to this if I apply it in the outer loop it will be from this to this point. I am doing +10 – 4i1 that is this then from this to this -2i1 and here zero nothing and you have read this point. And this is equal zero. + 10 – 4i1 and -2i1 is 0. So the second equation is from this equation you get 6i1 is equal to 10 or i1 is equal to 10 by 6 which is equal to 5 by 3 Ampere.

But this is not short circuit current short circuit current will be obtained now from this. So, i1 is known. 3 into 5 by 3 minus 6 ISC is equal to 10, or 6 ISC is equal to 50 by 3 minus 10 which is equal to 50 – 10 = 20/3 or ISC short circuit current is equal to 20 by 3 into 6 and this is 10 by 9 Ampere. Now what I am telling then Rth Thevenin’s is has to be Vth Thevenin’s by ISC. What is Vth Thevenin’s for volts? 4 divided by 10 by 9 which is equal to 36 / 10 which is coming, how much it is, 3.6 ohms.

So, this is another way of calculating Rth Thevenin's. Therefore, you should be careful when a network is having both dependent and independent sources. And if you are asked to calculate Thevenin's equivalent of a circuit, which having multiple number of dependent and independent sources, while calculating Rth Thevenin's and Vth Thevenin's we should be careful. To calculate the open circuit voltage, do not remove any source.

Calculate VXO only and KCL only whatever method you like and similarly to while calculating the Rth Thevenin's, between these two points replace the independent sources only by their internal angles and the, do not do anything with the dependent sources. Then two ways you can calculate Rth Thevenin's. One is then you excite the network with unknown voltage or current source, and then, find out the current drawn by the circuit. If we have exited this with the voltage source and then find out Rth Thevenin's.

Another way in a given network with so many dependent, dependent sources another way of telling this calculate open circuit voltage and calculate short circuit current and do not remove any source in this two cases. And then divide this 2 you will get Rth Thevenin's open circuit voltage will give you Vth Thevenin's. Hope you understood this. We will, in the next class will take slightly complicated circuit with dependent.

Mind you only one thing I would like to tell you that in a network, when both voltage and current sources will be present, which may be dependent, independent, whatever it is, suppose if I say find out the current in a particular branch by applying superposition then also you should be careful. So in a circuit, to what I am trying to tell is that when there will be several sources both dependent and independent sources present.

And if I ask you to find out a particular branch current by applying superposition theorem, then what you should do you should considered one independent source at a time and keep the dependent sources present do not play with them. They will remain intact to find out. And only because of independent sources, we will find out the currents in various branches. I think you have got the idea. Next time, I will solve a problem.

And so the calculation of Vth Thevenin's are somewhat tricky with Vth Thevenin's is tricky, that is although we replace the sources by their internal impedance but not with the dependent sources. Do not do anything. Let them be in the circuit. Let them be in the circuit. Similarly, while applying superposition, Rth Thevenin's, either you find out the short circuit current, dependent sources will be present always ok.

Anyway, go through this small exercise, but very on your own you try to solve and, and then, it will be much more clearer to you what exactly you have to do while calculating current in various branches of a circuit having both dependent and independent sources. Thank you.