Fundamentals of Electrical Engineering
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Lecture - 17
Methods of Circuit Analysis (Contd.)

So, we will have back again. So, look in this circuit, right.

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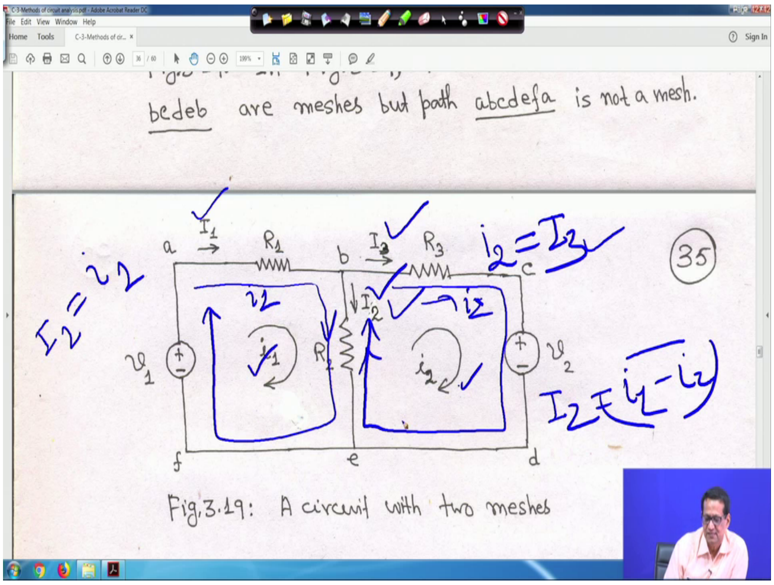

Then first you have to see that mesh and loop thing, right. So, question is that if you look path a b e f a; that means, a b e f a; that means, this one a b e f a, right, this one, right. So, this another one is your b c d e b, this a b e f a, another one is b c d e b. So, starting from here b c d e b, right, this is actually individual, this is actually mesh, this is a mesh, this is mesh because there is no no loop under your; what you call within that, but when you think about loop, then suppose I have making it, just it is a blue color.

If that color if I can make different color, things would better, but just try to understand, but if we make like these; like your a b c d e f a say a b c, then d, then e f a like this. So, this is a loop a b c d e f a, this is a loop because within this loop that 2 bold loops are there. So, it is a loop, but it mesh means there will be there, but this one and this one; it is a mesh, there is no loop within that, but if you take a b c like a b c d e f a, I will like this whole thing if you take like this. So, within that there will be another loop here, another loop here, it is called loop, right.

So, this is slight difference between loop and mesh, but loosely sometimes, we talk either loop or mesh, right, but this is the difference between the loop and mesh ok. So, let me clear it, right so; that means, if you take; if you if you take just hold on; if you take if you take like these, if you take complete thing like these, it is a loop, right, it is a loop. Suppose, we are taking it as a loop, but within that within that; this is this is a mesh because there is loop, there is no loop within that right. So, this whole thing is a loop, but within that also 2, this 2 loops are there. So, it is a loop, but if you take this loop, there is no loop within it, here also there is no loop within it, at that time, we call mesh, right. So, this is mesh 1, this is mesh 2 and you have this single loop, hope you have understood the slight difference between mesh and loop, right.

So, let me clear it, right. So, here if you look into the circuit, if you look into the circuit, then this current capital I 1, we have taken this is capital I 2 we have taken and this is capital I 3 we have taken, right and the and the cyclic current i 1, i 2, we have taken, this isi 1 and this is i 2, the cyclic current we have taken, right. So, in the then in this case, you are what you can do is the first you see this i 1 current, first you see how things are this current, this i 1 current for your understanding, it is going like this, right. So, this is your i 1, right; that means, and this is capital I 1 so; that means, my capital I 1 is equal to small i 1 here, right.

Now, if you take this I 2, it is going like this going like this. So, this this I 1 this I 1 if you take, it is coming down and this i 2 if you take, it is going up this small i 1 and small i 2. So, what will be the i 2 then; capital I 2 then? This is capital I 2. So, direction is downwards and this i 1 direction is downwards and this is going upwards. So, it is i 1 minus i 2, this is capital I 2, right is equal to i 1 minus i 2 and I 3 is equal to this current is actually i 2 because it moves like this, right, this is actually i 2; that means, my small i 2 is equal to capital I 3, this way, this cyclic current; this way things will be easier for you to understand, right.

So, now so that I 1 is equal to small i 1 is equal to capital I 1 small i 2 is equal to capital I 3 and downward direction I 2 is equal to I 1 minus because I 1 moving downwards. So, resultant is I 1 minus I 2 because we have taken this cyclic current, right. So, let me clear it so; that means, now you apply your this is your mesh 1, now you apply your KVL in your mesh 1 because mesh analysis, we have to apply KVL and nodel analysis, we have to we are applying KCL, right.

So, in this case, but if it is a super node, then of course, we have seen KCL and KVL both require. So, in this case, if we apply write down your what we call that your KCL right KVL in mesh 1 and mesh 2, then you will get this 2 equations, I did not write now why because things are very easily understandable for you.

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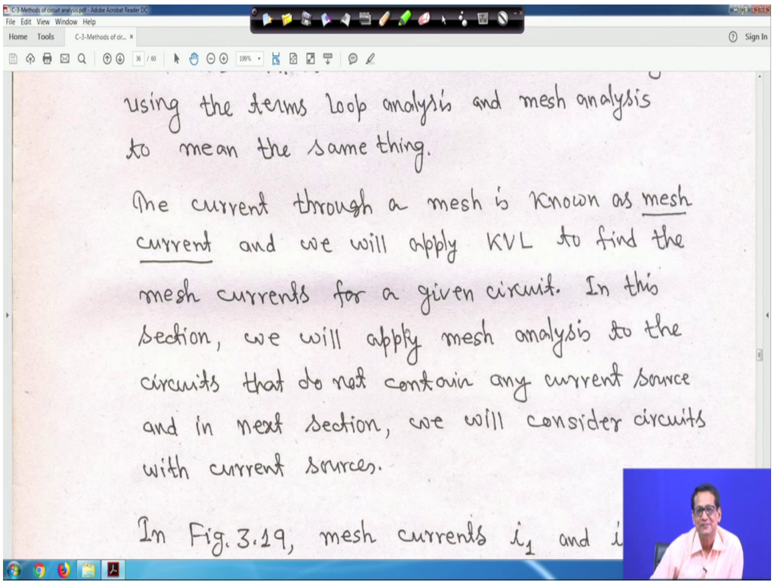

So, all this right up is there, you can go through it whatever I have told everything is written here, but some places, you can find detail in a book. So, please see it in a chapter, there is no such book it is completed, right.

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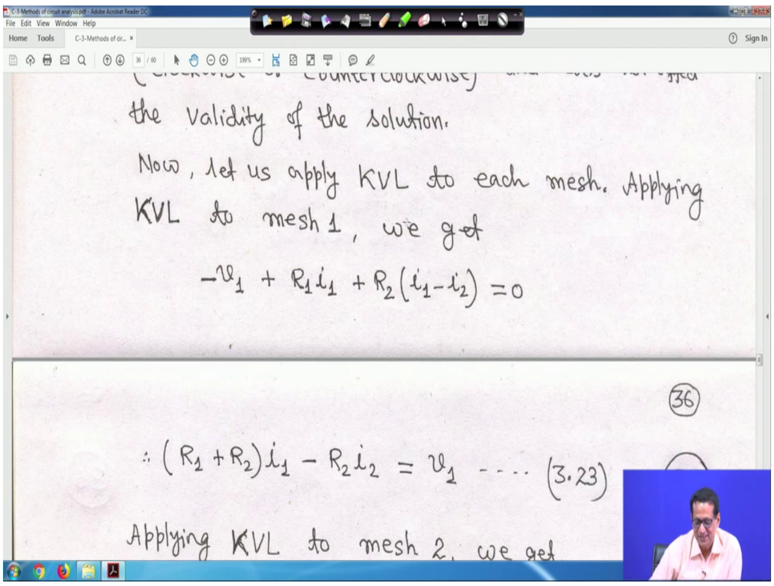

So, if you write your mesh 1 and mesh 2 that your KVL, you will get minus v 1 plus R 1 i 1 plus R 2 into i 1 minus i 2 is equal to 0, right; that means, if you simplify, you will get R 1 plus R 2 i 1 minus R 2 is equal to v 1; that means, here if you apply KCL in this, your KVL in this mesh. So, it will be i 1 R 1, right, then your plus i 2 into your i your i 2 into R 2 minus v is equal to 0 i 2, we have told that i 1 minus i 2. So, upon making all these thing, these one, you will get finally, it is coming R 1 plus R 2 i 1 minus R 2 i 2 is equal to v 1.

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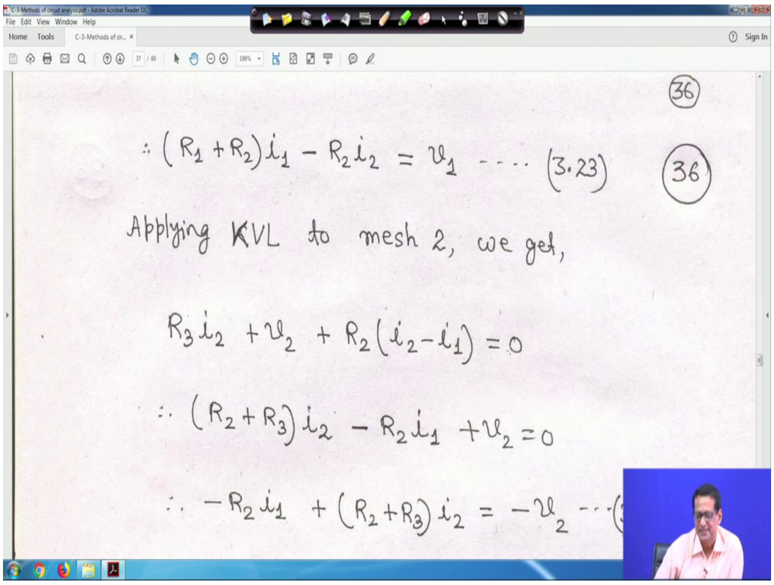

Similarly, you apply KVL to mesh 2, right, you apply your; what you call KVL to mesh 2. So, if you do. So, it will be simply like this I your i 3 R 3 plus v 2 plus your R 2 into i 2 minus i 1, right. So, here i 3 R 3 R 2 i 2 plus v 2 plus R 2 into i 2 minus i 1 is equal to 0, straight forward, you can write, right because when you are moving in a mesh 2 i 2 is upward. So, they are moving clock wise and i 1 downwards; i 1 downwards; so, i 2 minus i 1; so, understandable.

So, after that; you simplify this is equation your 24 and then put them in that simple matrix form.

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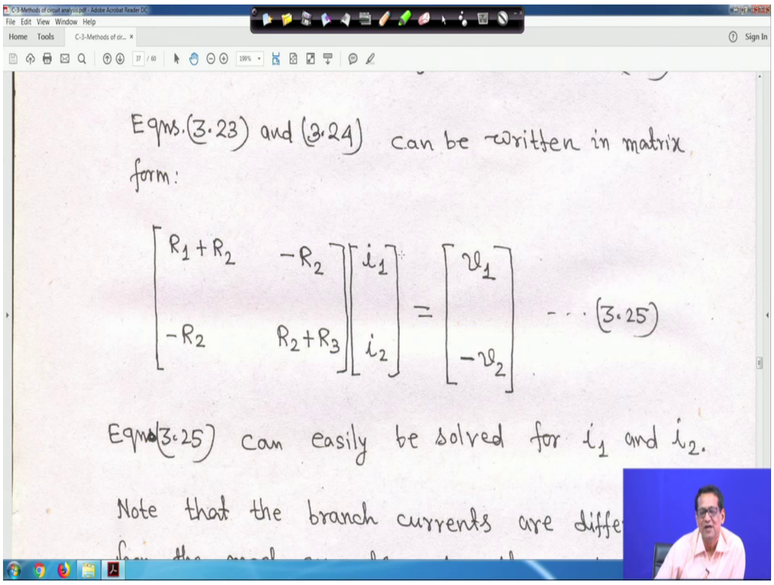

So, this is your v y v 1 v 2 known if R 1, R 2, R 3, all are known. So, you solve for i 1 i 2 cyclic current right and if small i 1 i 2 is known, then i 1 is equal to capital I 1 is equal to small i 1, we have seen then capital I 3 is equal to small i 2, we have seen in the diagram and then i 2 is equal to your what you call in the direction is downwards. So, it will be i 1 minus i 2, right.

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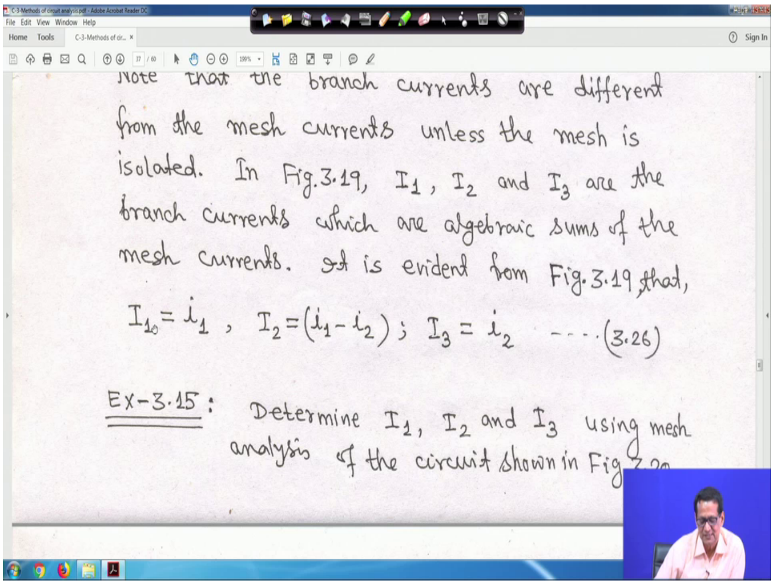

This is your this, we have seen I 1, I have given you I 1 is equal to capital I 1 is equal to small i 1 capital I 2 is equal to I 1 minus I 2 in the direction in downwards as per this diagram and I

3 is equal to I 2 as per this diagram, this your this I 2 is the downward direction, right.. So, now within this, this is the mesh analysis; so, your what you call that your determine I 1, I 2, I 3 using mesh analysis of the circuit shown in figure your 20, right.

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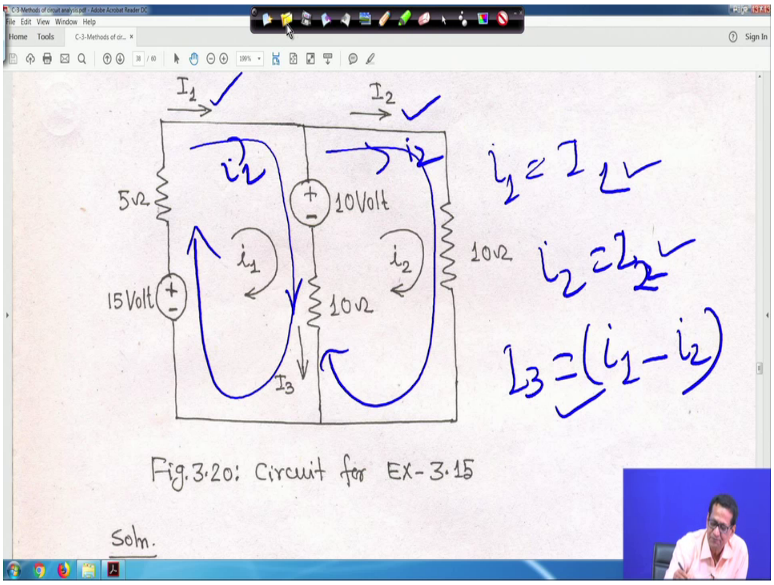

So, we have to apply your mesh analysis ah; that means, KVL this is 1 mesh; this is another mesh, you apply KVL and accordingly, you find out only thing is that 1 voltage source is here. So, if you if you look into that that this I 1 is going like this, it is going like this right. So, small i 1 is equal to capital I 1 this I 1, you have to find out, then small i 2, this is also going like this, right. So, this small i 2 also capital I 2, right, if this capital I 2 because this is your I 2 same direction, this is your I 1; that is small i 1 same direction, right.

And I 3; this I capital I 3 it is in downwards. So, this I 1 is downwards right and this small i 2 upwards. So, resultant is this one, right. So, once you solve I 1 and I 2, then you find out I 1 is equal to capital small i 1 is equal to capital I 1, small i 2 capital I 2 and this is I 3. So, you can now easily apply your KVL, I need not I need not tell much now, right. If you apply as a for example, one I 1 equation, I I am writing suppose I am moving like this, I am moving like this. So, plus 10 volt, it is encountering first. So, let me clean it, then I will write, right.

So, if you if you apply your here your KVL.

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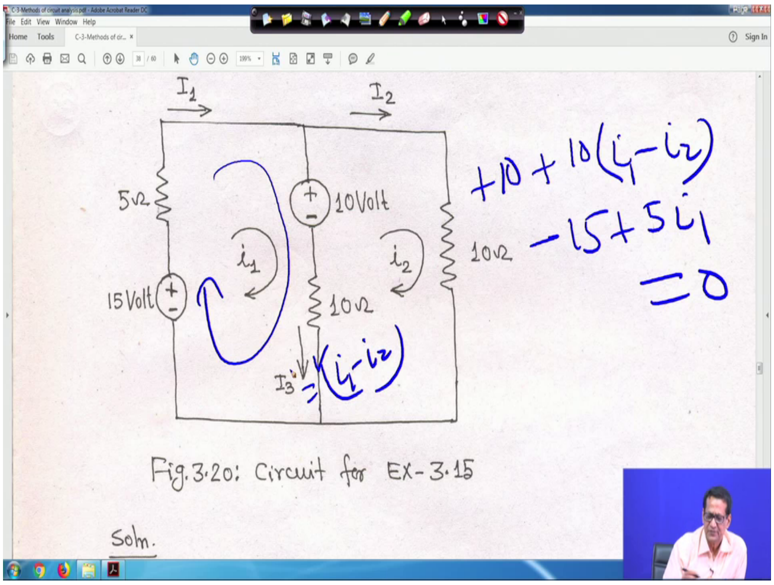

So, it is moving like this. So, it will be plus 10 because it is encountering your 10 volt plus right, then it is it will be your what you call this plus 10 into i 1 minus i 2 into i 1 minus i 2 right because we are going we are moving clockwise. So, resultant current here in this branch in this direction, it is if you go this way it is i 1 minus i 2 moving like this then encountering minus terminal first of this voltage source. So, minus 15 right then your plus your 5 by 1 is equal to 0 right.

So, I hope I have not missed anything, right. So, if you simplify you will get that relationship i 1, i 2, similarly, here also same way you do, right. So, let me let me clear it.

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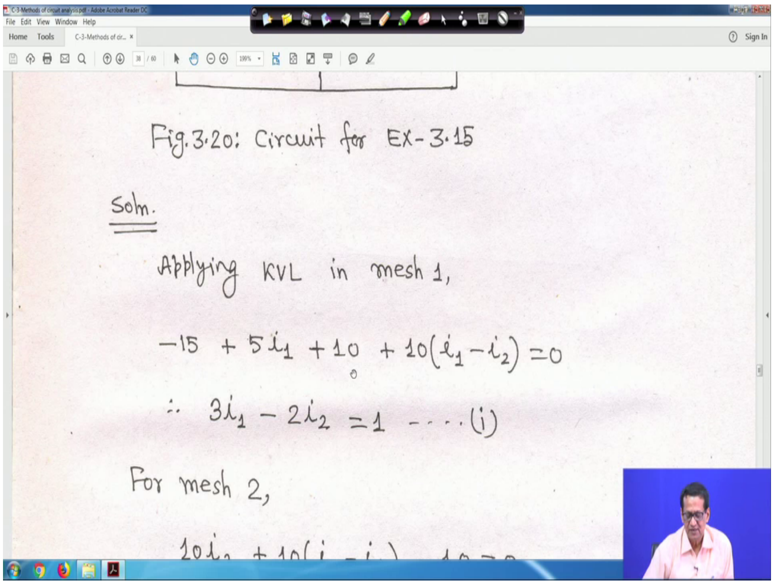

So, if you if you do so, here I written minus 15 whatever I said minus 15 plus 5 i 1 plus 10 plus 10 i 1 minus i 2 is equal to 0, I told you that you write it is plus 10 volt. So, plus 10 is coming move like this, then 10 into i 1 minus i 2. So, 10 into i 1 minus i 2, then you are moving like this. So, minus 15; so, minus 15 is here, then plus 5 i 1 plus 5 i 1 is equal to 0 simplify 3, i 1 minus 2, i 2 is equal to 1, this is equation 1.

Similarly, for mesh 2, if you apply mesh 2, if you moving clockwise. So, 10 into i 2, right that is your 10 into i 2 is here 10 into i 2 is here plus, you are moving this way, now clock wise this way. So, you are moving, I mean I mean you are moving these way now. So, going clock wise this way. So, it will be i 2 minus i 1 into 10, right. So, may clear it, right.

So, it will be 10 into i 2 minus i 1. So, 10 into i 2 minus i 1 and then encountering minus terminal, first of this 10 volt source; so, minus 10; so, here it is minus 10 is equal to 0; that means, i 1 minus 2, i 2 is equal to minus 1, this is equation 1. So, equation 1 and 2, you solve.

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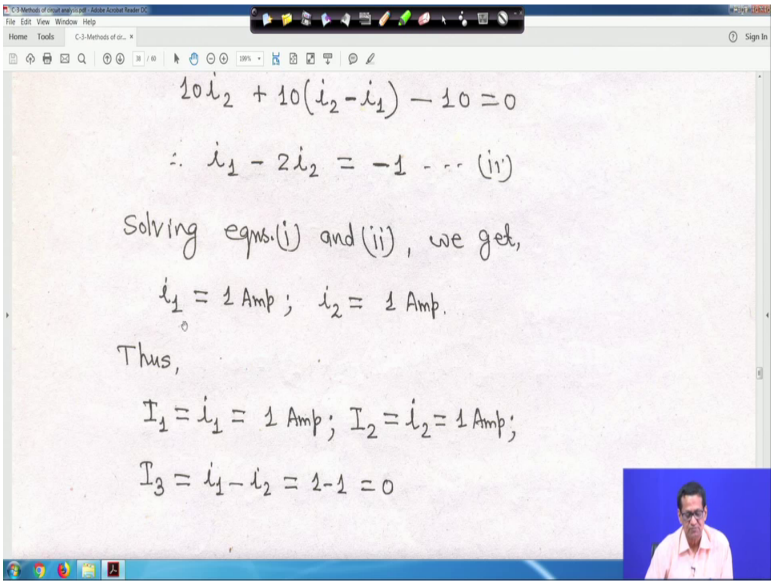

If you solve, you will get small i 1 is equal to one ampere and small i 2 is equal to also 1 ampere. Thus capital I 1 is equal to i 1 and I told you at the beginning it is 1 ampere I 2 is equal to small i 2 is 1 ampere and capital I 3 in the direction is downwards I 1 minus I 2 that is equal to 0; that means, in that second branch there is no current flowing, right.

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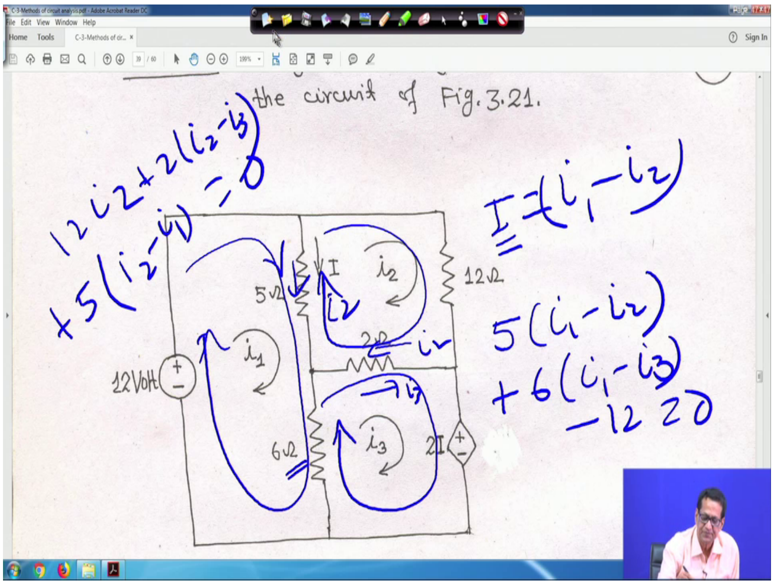

So, let us take another example using mesh analysis determine I in the circuit shown in figure 21. So, we have to find out that I the question is this one; this is a dependent voltage source, right, this current actually I flowing through this current is I and this is a dependent voltage source and you have to you have to your; what you call follow the same procedural, right we have your 1 mesh, 2 mesh and 3 meshes are there. So, accordingly you have to your; what you call you have to solve; that means, when you are when you are making in this branch.

So, let me clear it, right where you are making the this branch right in this branch. So, this when you are move moving like these you are moving like these, right; so, this current is your what you call I 1, here it is written everything, but for your understanding we will making this your what you call this showing in bigger way, right.

So, this current actually and this current is going like this and this one going like this right. So, in this case, if you if you look into this so, that 5 ohm to the 5 ohm resistance the current in the, that I in that I downwards. So, I is equal to actually this i 1 it is actually i 1 minus i 2 because i 1 is coming downwards and this is going upward this i 2 is going upwards. So, it is I is equal to capital I is equal to i 1 minus i 2, right.

Similarly, here in this 6 ohm resistance 6 ohm resistance when you see that there what is that voltage drop across 6 ohm resistance it will be actually because we have to apply your what we call that your KVL. So, if you apply KVL, then it will be 5 into i this i. So, 5 into actually i 1 minus i 2, then here you have to apply plus 6, i 1 is up downward it is upward. So, it is i 1 minus i 3, this one; then encountering negative terminal first minus 12 is equal to 0. So, you can easily write this equation. This is a first equation for mesh 1.

Similarly, for mesh 2, if you apply, if you look; if you look into that move like this, it will be 12 into i 2 because 12 into i 2, this is mesh 2; 12 into i 2, right, you are moving this way. So, this is your i 2 and this is your i 3 because you are taking clock wise here also clock wise moving this way. So, plus 2 into i 2 minus i 3, right your plus 5 into i 2 into minus i 1 is equal to 0, right. So, this way you can write all this equation. So, mesh 2. So, let me clear it right.

So, if you if you come to that third equation will come later.

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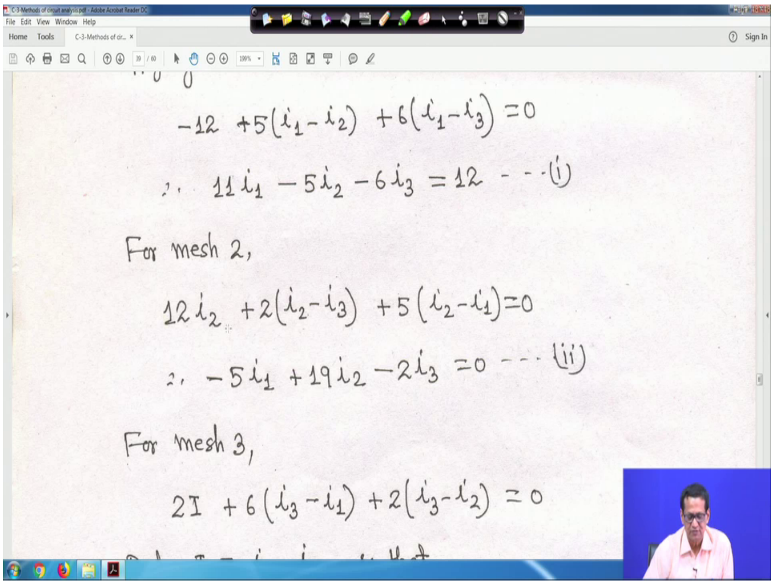

So, if you come to that that first equation, I wrote second equation for mesh 2 also, we wrote right and if you simplify, it will be 11, i 1 minus 5, i 2 minus 6, i 3 is equal to 12. Similarly for mesh 2 minus 5, i 1 plus 19, i 2 minus 2, i 3 is equal to 0. This is equation 2. Now if you come to the, this third mesh 3, right, we are moving like this, we are moving like this, right. So, it will be actually 2 into i 3 minus your i 2, right, just hold on I just I am telling from my your; what you call from my mouth, just listen, it will look at the mesh 3, this is your mesh 3, right, it will be 2 into i 3 minus i 2, just if you the already I have explained because I moving clock wise. So, i 3 and in this direction, right; so, i 3 minus i 2; so, if you look into that it will be 2 into i 3 minus i 2, I am telling this term first 2 into i 3 minus i 2.

Next is next is your plus; this dependent source plus 2 I plus 2 I means that I is equal to your earlier I said that I is equal to your i 1 minus i 2 right because this is the I this is I I said earlier and this is 2 i; that means, 2 i 1 dependent source 2 i 1 minus i 2.

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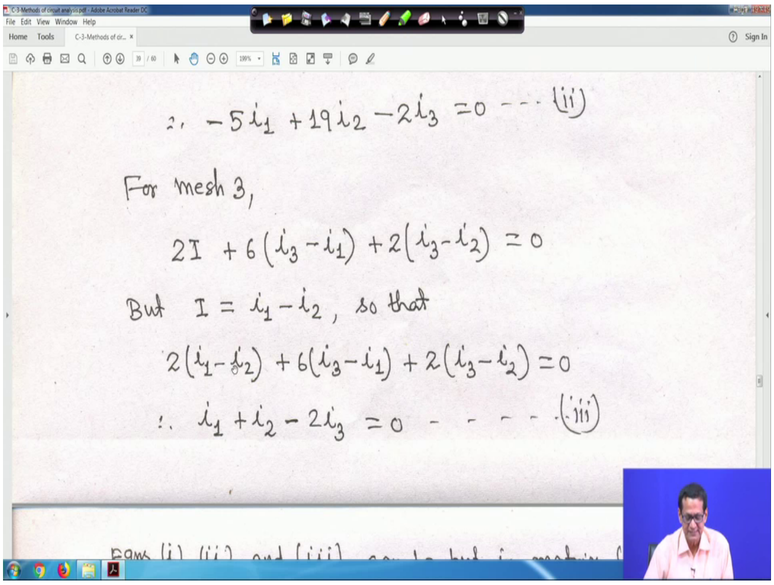

So, plus if you look into that plus your 2 your i 1 minus i 2, here it is plus 6 into i 3 minus i 1 plus 6 moving clockwise. So, the current going when moves upwards, it is 6 into i 3 minus i 1. So, plus 6 into i 3 minus i 1, right.

So, this is your plus 6 into I, if you simplify this, it will be i 1 plus i 2 plus minus 2; i 3 is equal to 0, this is equation 3. So, equation 1; equation 1, 2 and equation 3, you have to solve, if you make it in matrix form and solve any way Clammer's rule and anyway you want, right.

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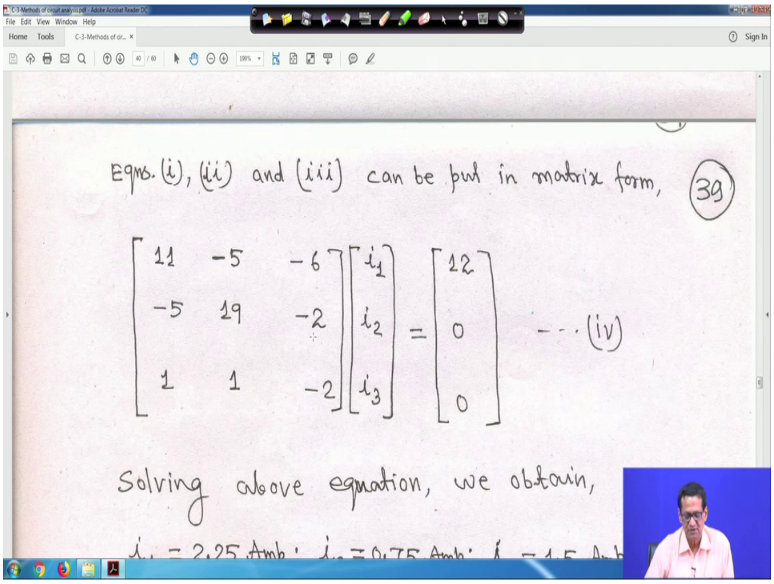

You will get i 1 is equal to 2.25 ampere, i 2 is equal to 0.75 ampere.

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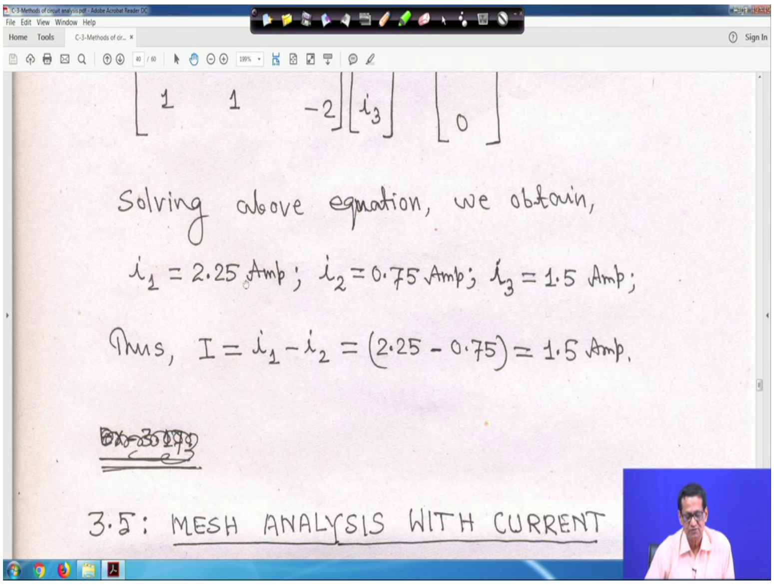

And i 3 is equal to 1.5 ampere; that is capital I is equal to i 1 minus i 2. So, it is coming 1.5 ampere, right.

So, this is whatever we have seen those problems and little bit of explanation that is your without any current sources for the mesh analysis earlier whatever we have saw we saw it is only with the voltage sources we have not seen any your what we call current sources, right. So, now, we will analysis mesh analysis with current sources. So, in this section we will apply mesh analysis to circuit that contain dependent or independent current sources, right.

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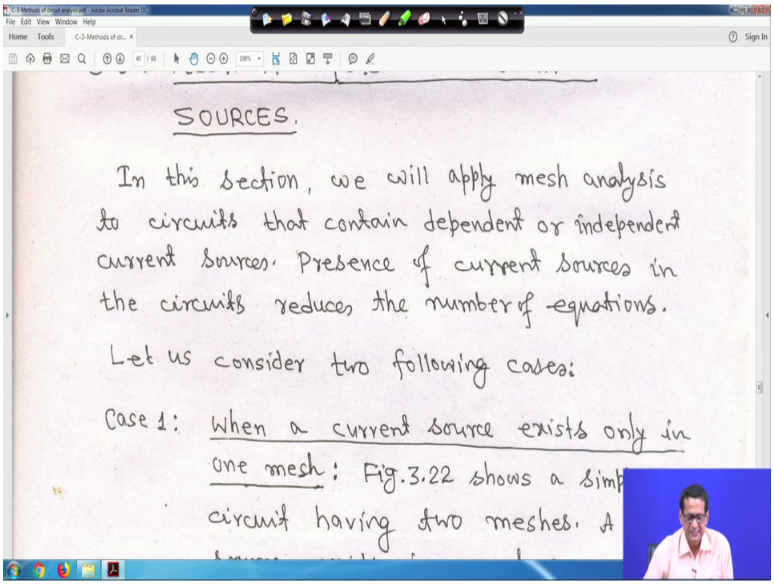

So, presence of current sources in the circuit, it reduces actually the number of equations. So, we have to consider 2 following cases when a current source exist only in one mesh; that is figure.

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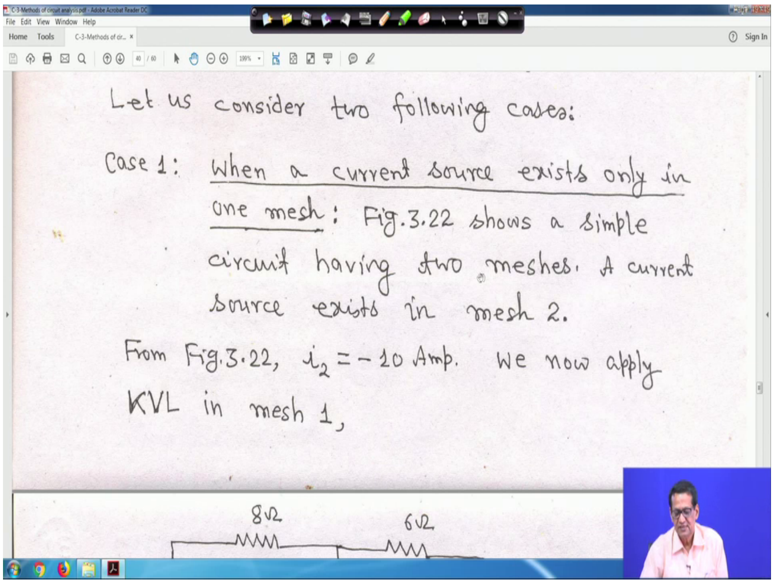

So, I will show you a simple circuit having 2 meshes current source exist in mesh 2, right.

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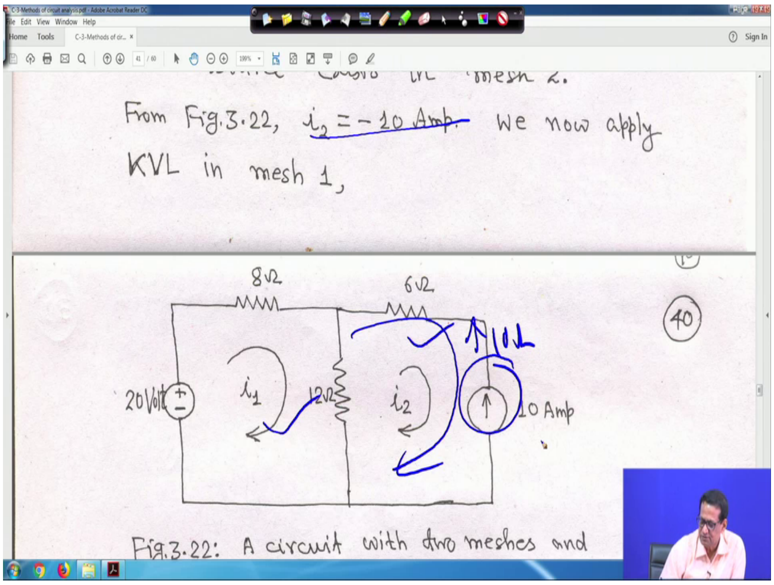

So, in this case, suppose this is your this say current source, there are 2 mesh and 1 one current source is exist, this is 1 mesh and this is another mesh and 1 current source is simply exist in this. So, if you look into that right. So, what is the first you have to find out what is the value of i 2. So, we have taken like these clockwise. So, we have taken like this, but this 10 ampere it is your upwards this 10 ampere is upward. So, i 2 is equal to minus 10 ampere that is shown here i 2 is equal to minus 10 ampere. So, number of equation not 2 here, number of equation will be 1 because in another mesh the current source is there. So, it reduces the number of equation.

So, directly you can write i 2 is equal to minus 10 ampere, right. Now if you apply your KVL in the in mesh 1, then it will be your if you look into that I am writing I am writing for you let me let me clear it, right. So, if you your what you call if you apply your KVL in mesh 1.

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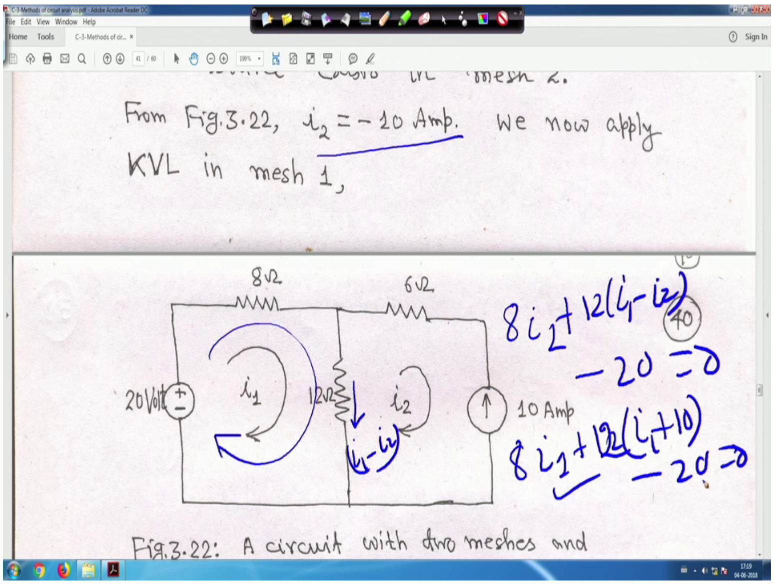

Then it will be 8 into i 1 8 into i 1 and resultant current flowing in this direction it is i 1 this is going i 2. So, it is i 1 minus i 2 in this direction. So, plus 12 into i 1 minus i 2 right and minus twenty is equal to 0, right.

But i 2 is equal to minus 10 ampere that we have explained, right. So, if you put i 2 is equal to minus 10 ampere. So, it will be i 1 plus 12 and it is i 1 and i 2 is equal to minus 10 ampere so; that means, it will be plus 10, right minus 20 is equal to 0, from here, you can find out; what is i 1 because this is only this is 12, right. So, it is i 1. So, from that we can find out what is i 1. So, let me clear it solution is given, right. So, in this case; your i 1 is equal to minus 5 ampere, this is the answer, right.

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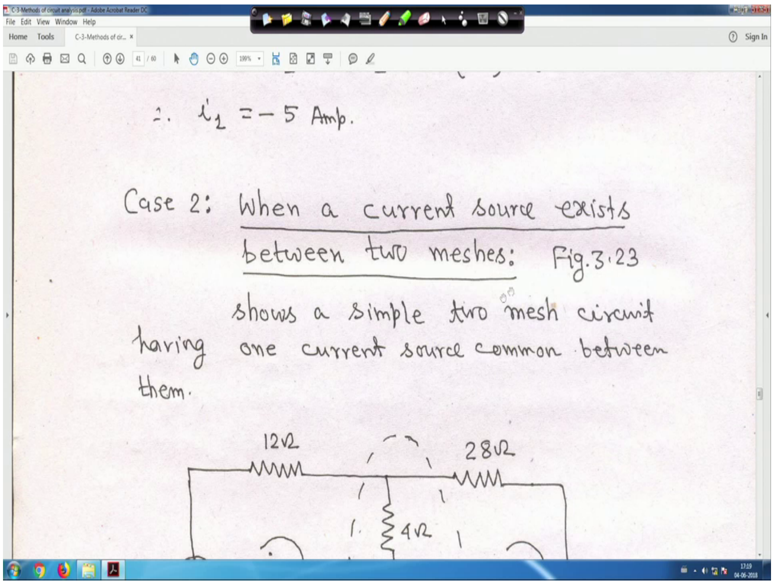

Now, when a current source exist between 2 meshes, right, suppose a current source exist between the 2 meshes. So, then what will happen?

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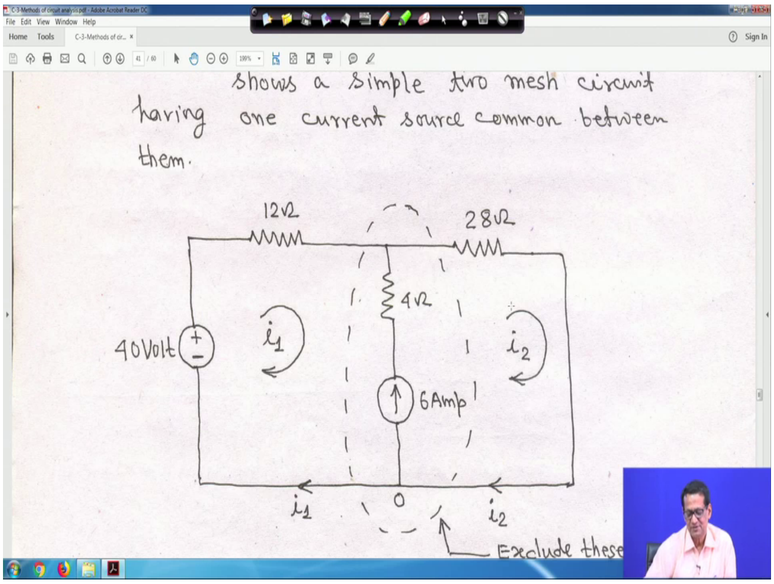

So, just look at this circuit, let us look varieties of examples, we have taken such that you should not get, you should not be any you know you; there should not be any confusion ac circuit also similar thing will be there, but we take less number of examples when you see that because complex number will involve, it takes time to solve right, but concept will remain same.

So, question is that that whenever you have a if there are 2 meshes there are 2 meshes in between, you look a current source is there, a current source is there and along with that one 4 ohm resistance is also there is in series with this current source, right. So, what you can do is. So, let me let me let me clear it. So, so, what you can do is exclude these elements.

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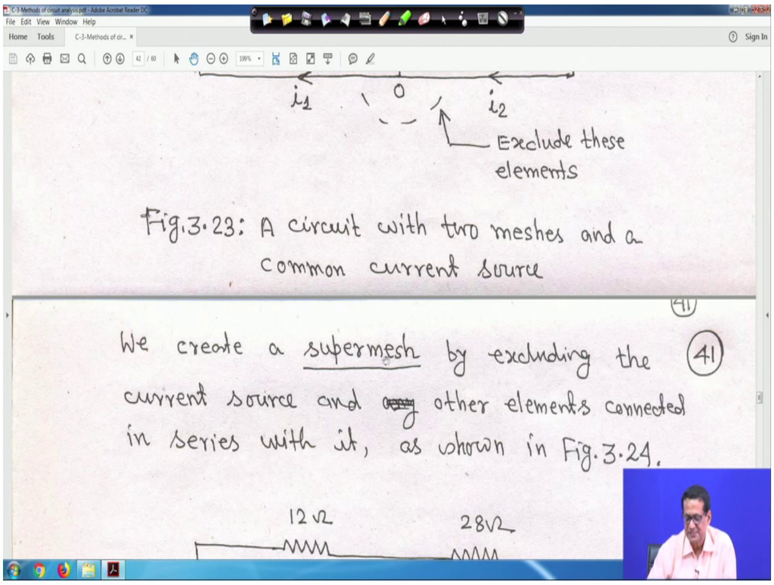

Exclude this elements means that we create a super mesh by excluding the current source and other elements connected in series which it as shown in figure this, right.

So, exclude this element because we have by excluding this we are creating a super mesh like super node we have studied.

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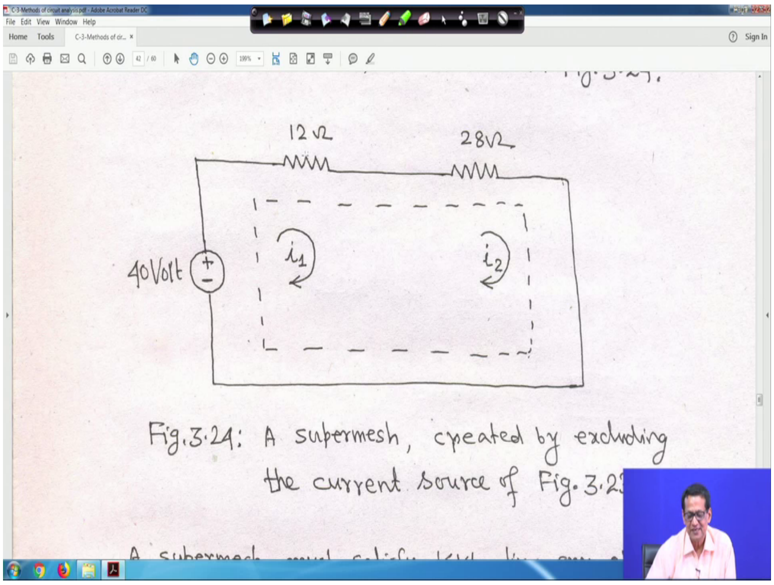

Now, we will create a super mesh. So, in this case what will happen? By excluding the current source and the other elements, this is at it is shown in that this there is a super mesh is created, right, but it is your what you call this current is i 1 this current is i 2, right, but do not consider a same current 12 ohm 28 ohm this is flowing no not like that. So, a super mesh is created.

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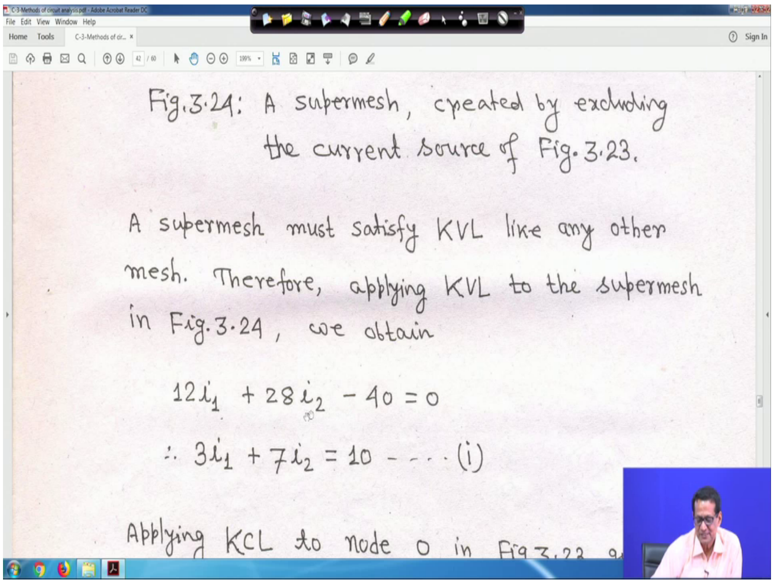

So, now, in this case, you apply your what you call the KVL a little bit 12 into i 1 plus 20 into i 2 minus 40 will be is equal to 0, look 12 i 1 plus 20 i 2 minus 40 is equal to 0.

Because this super mesh is created and you exclude this you exclude this right in other way, in other way, if it is there in other way basically you are applying KVL in this loop, right. So, if you applying KVL in this loop, then it is basically 12, i 1 this one 12 i 1, then here also plus 12 i 2 sorry 20 28 i 2 and minus 40 because encountering negative term is equal to 0.

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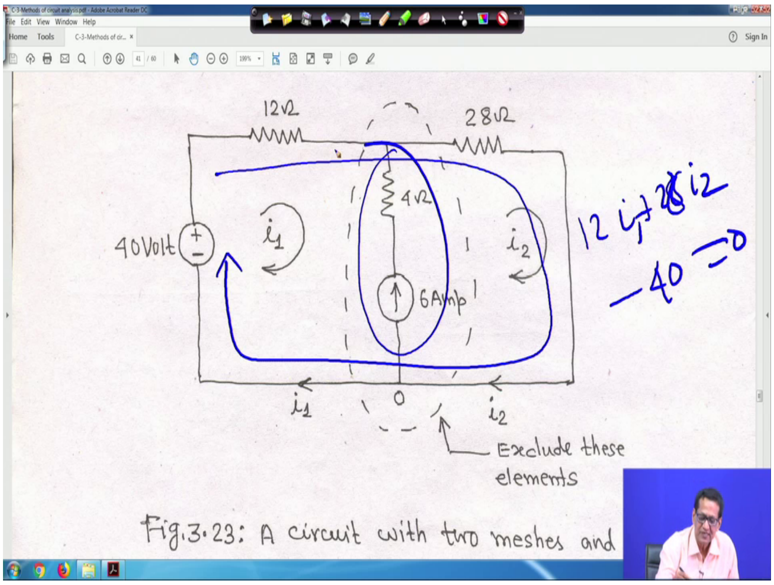

So, basically you are you are just keeping this one you exclude this one a super nodes is created exclude this one. So, this way same we were writing right let me clear it right let me clear it. So, this is your i 1 and this is super mesh is created this way same equation I showed you how to write. So, this is your if you simplify 3 i 1 7 i 2 is equal to 10 apply KCL to node o in figure 3 gives this one. Now second thing is you apply KCL at node o; that means, let me these thing this is your node o right it is o. So, question is that here this 6 ampere current actually.

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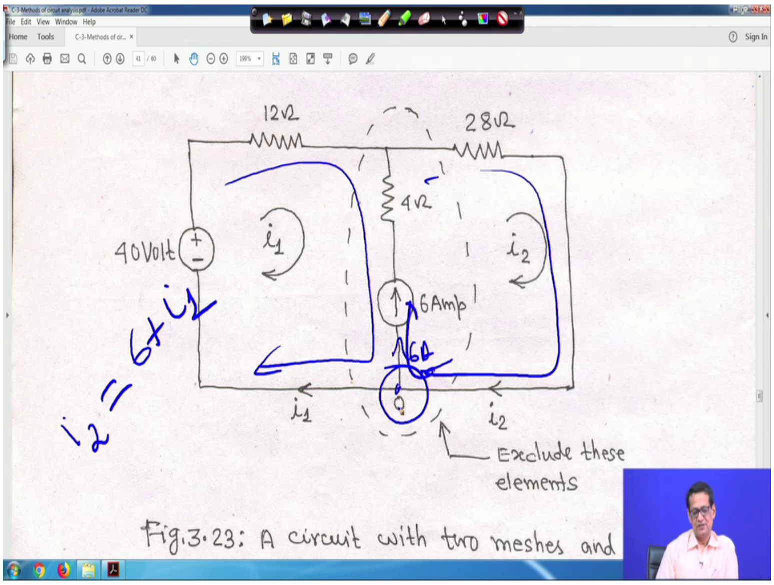

This is upward direction. So, this is 6 ampere, it is leaving the node and this i 2 is actually entering into the node and this i 1 is leaving because current i 1 goes like this current i 2 also goes like this, right goes like this right. So, basically this i 2 is entering at this node. So, i 2 is equal to your 6 plus your i 1, right.

So, KCL you apply at this node, right. So, let me clear it. So, that is why we have written here that i 1 plus 6 is equal at or i 1 is equal to i 2 minus 6.

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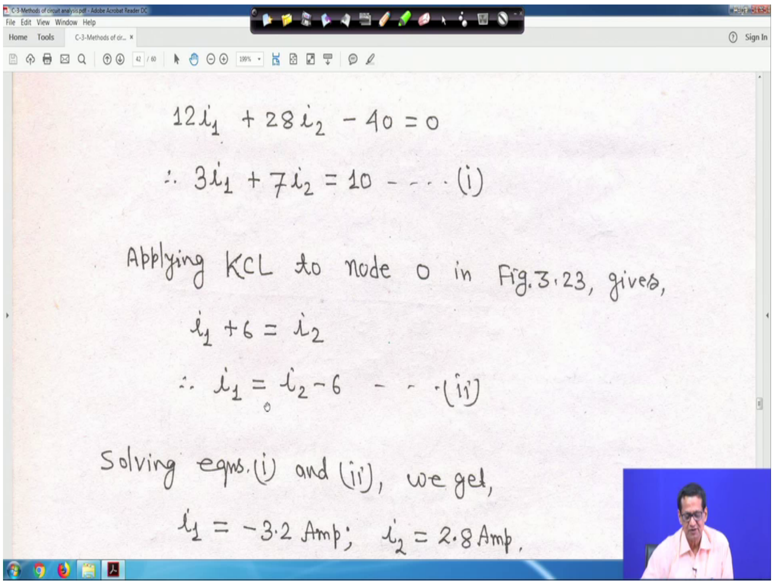

Now, solve this equation 1 and 2; if you solve, you will get i 1 is equal to minus 3.2 ampere and i 2 is equal to 2.8 ampere, therefore, a super mesh has the following property, one is a super mesh has no current of its own right.

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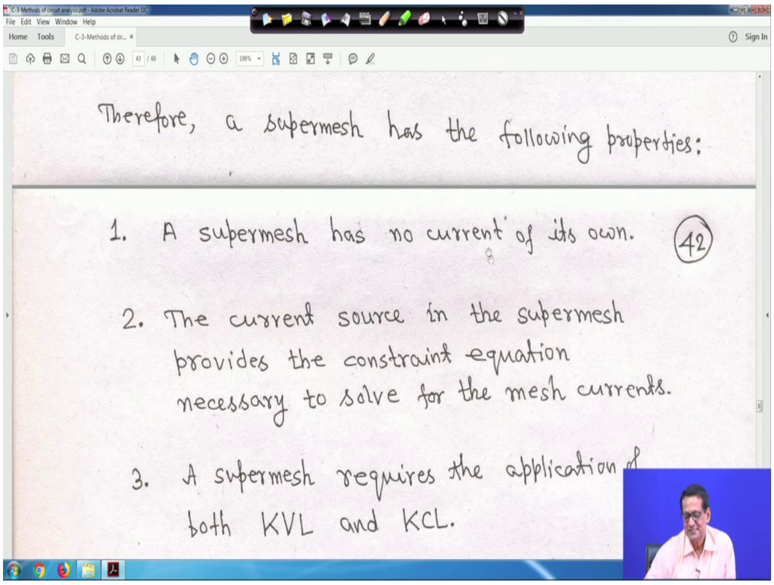

This is your this is your this is the first thing a super mesh has no current of its own

Second one is the current source in the super mesh provides the constant equation necessary to solve for the mesh current. So, which is constant equation let me let me clear it. So, here because this is actually this equation actually your constant equation this equation the, this equation is your constant equation this equation because we apply KCL at node o because that is why it is a constant equation otherwise you cannot solve it right.

So, whenever you are excluding the super mesh then you have to you have to think that one your KCL had I have to apply. So, get that other equation then only I can solve it because using that loop or super mesh concept I got one equation. So, and that and another thing is in the super mesh you have to apply KCL and that is applied and this is the constant equation right, let me clear it and the third one is super mesh require the application of both KVL and KCL because like your nodal analysis also we have seen super node KVL and KCL here also KVL is required at the same time the constant equation here is KCL, right that is must, right.

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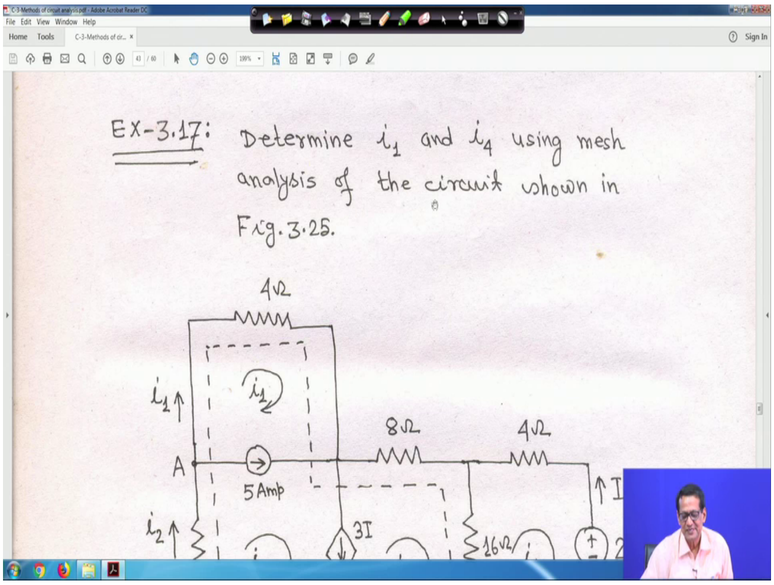

. So, take another example this is a bigger one it determine i 1 and i 4 using mesh analysis of the circuit shown in figure this, right.

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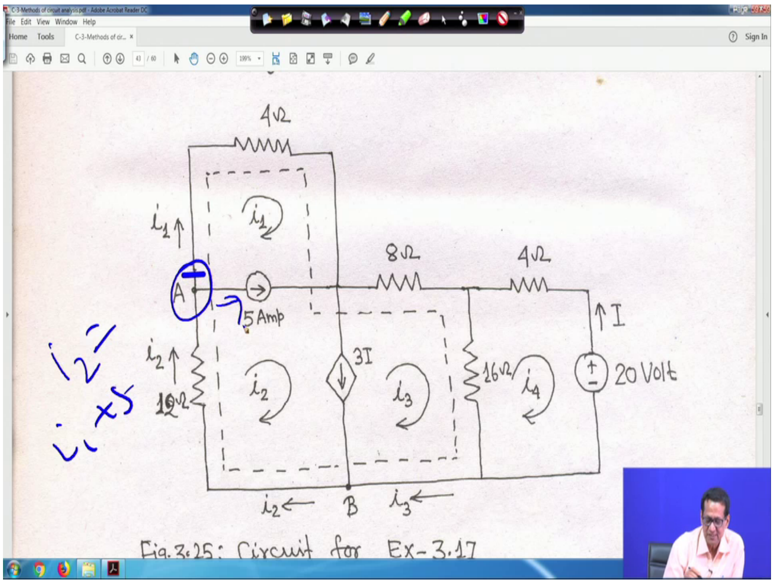

So, in this case, what will what you can see is first look at the problem. First look at the problem, this is 1 mesh and this is another mesh, this is another mesh, this is another mesh, there are 4 meshes; between these 2 meshes 1 cavern your what you call 1 your what you call that current source is there and right, therefore, as the as I showed previously 2 meshes are there and in between your current source is there. So, its creates a super mesh, right.

Similarly, between these mesh and these mesh, another dependent current source is there, this is independent current source this is. So, this is also creating another super mesh. So, this super mesh and this super mesh they intersect, right, finally, they created the, this super mesh. So, let me clear it, right.

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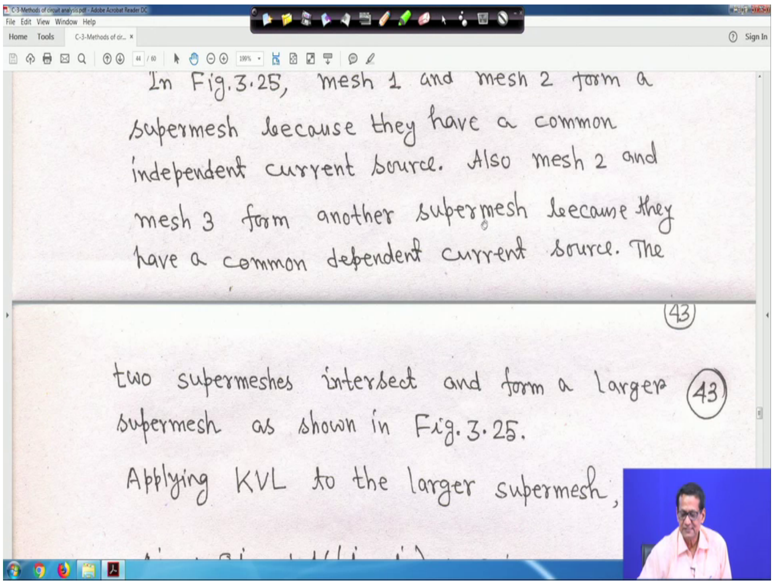

So, ultimately this whatever is there. So, become they have a common dependent currents I told you intersect and this actually finally, it is become a bigger or a larger super mesh.

So, ultimately your this is I should repeat again, this is a current source between this mesh and this mesh creating a super mesh also, this is another mesh, this is another mesh. So, dependent current source is there, it is independent creating another super mesh. So, these 2 super mesh your intersect each other and finally, dash line this creating a your what you call larger super mesh right based on that we have to apply right we have to solve this circuit.

So, hope you have understood this right. So, dash line is a actually larger super mesh. So, here if you see, all right of is there whatever I am telling, all right of is there when you listen to this you pause it and just note it down right if you have anything.

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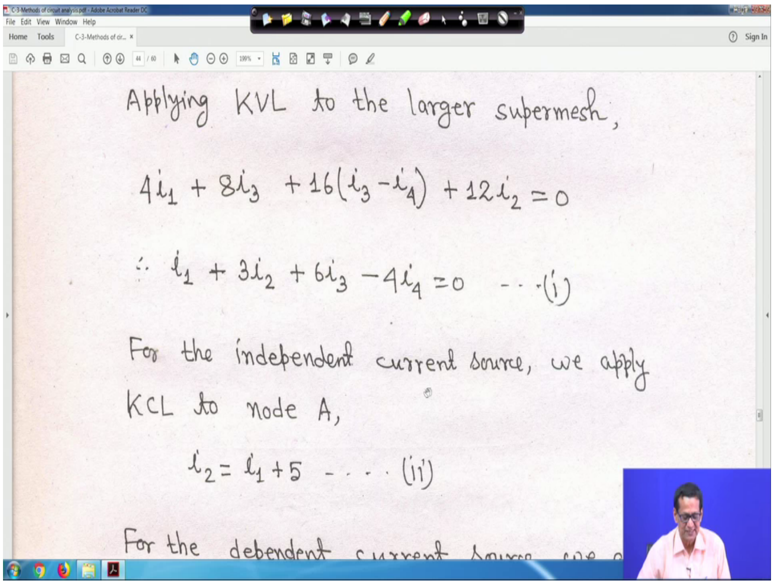

So, now, applying KVL to the larger super mesh you will get. So, this larger super mesh you apply KVL this is 4 i 1 this is 4 i 1 plus your this is your 8 i 3, right and plus this is your 12 i 2 right if you look into if you look into that is equal to your is 0 right 4 i 1 A one thing I have missed 12 i 2, 8 i 3, 4 i 1, another one, I have missed right; that is your this. So, 16 is here 16 i 3 minus i 4 because it is we have moving like this, this 16 i 3 minus I 4 because we are moving clock wise we are moving in the super mesh right we are moving like this like this right. So, 16 i 3 minus i 4 here it is coming is equal to 0.

So, let me clear it right. So, this is one equation you got right. So, after simplification i 1 plus 3 i 2 plus 6 i 3 minus 4 i 4 is equal to 0 for the independent current source we apply KCL to node a. So, if you apply KCL here if you apply KCL here at node a node a you apply KCL here, right. So, this; if you if you think that this i 2 this i 2 your is equal to is equal to i 1 plus 5 because this current is entering and i 1 and 5 ampere this 5 ampere current source. So, leaving; so, it is i 1 is equal to i 2 plus 5, right. So, just hold on. So, this is you your applying KCL at node a. So, if you are applying KCL at node a you get i 2 is equal to i 1 plus 5, I told you for the dependent current source, we apply KCL to node B.

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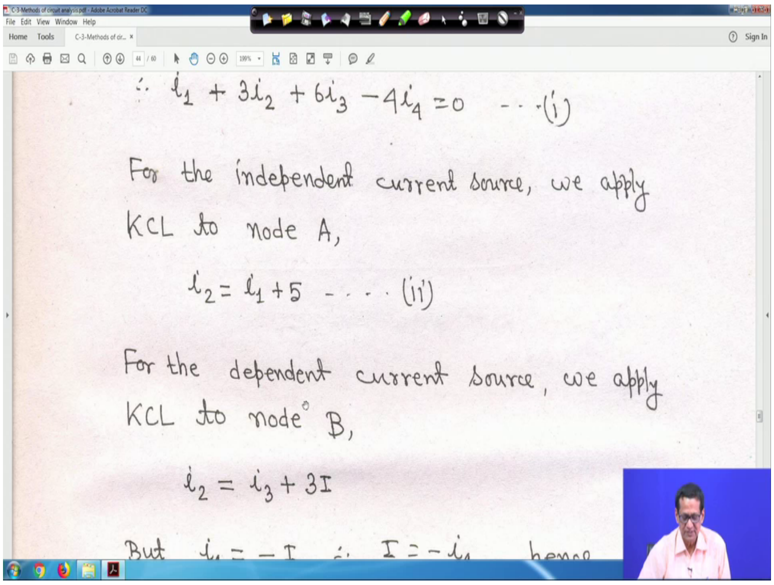

So, for dependent current source, this is another node is here, right, another node is here right. So, for dependent current source we apply KCL at node B, in this case, what will happen that this current your what you call this is a dependent this is a dependent current; this is actually I and this is actually 3 I, this is a dependent current source, right. So, if you apply then your KCL at this point earlier, we are applied here.

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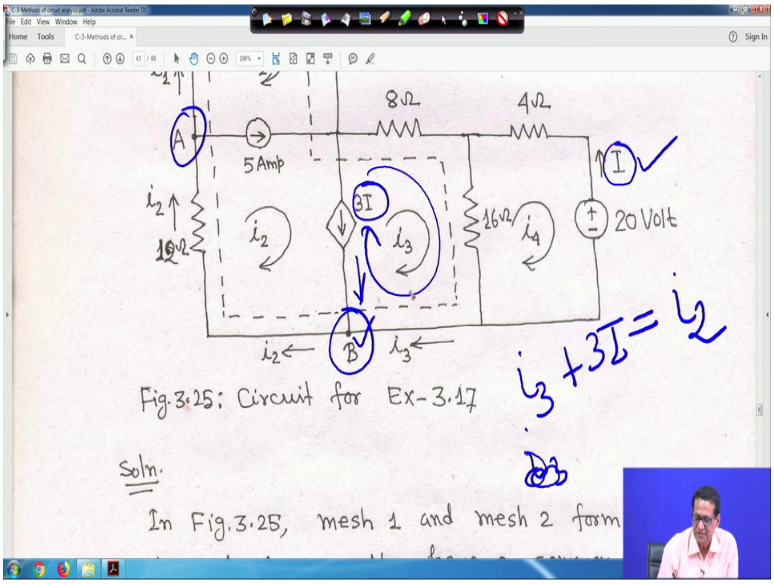

Now, you apply KCL at this thing, then this current actually entering this i 3, right and this 3 I current also coming here this 2 are entering plus 3 I is equal to your what you call i 2, right.

So; that means, if you let me. So, i 3 plus 3 I is equal to this I actually here it is a dependent your what you call dependent current source right. So, another thing is that this i 3 actually moving like this, right. So, basically your what you call, but anyway you are applying this later I will come to that. So, applying your i 3 plus 3 I is equal to i 2. So, let me clear and go back to that equation at KCL at node B, right.

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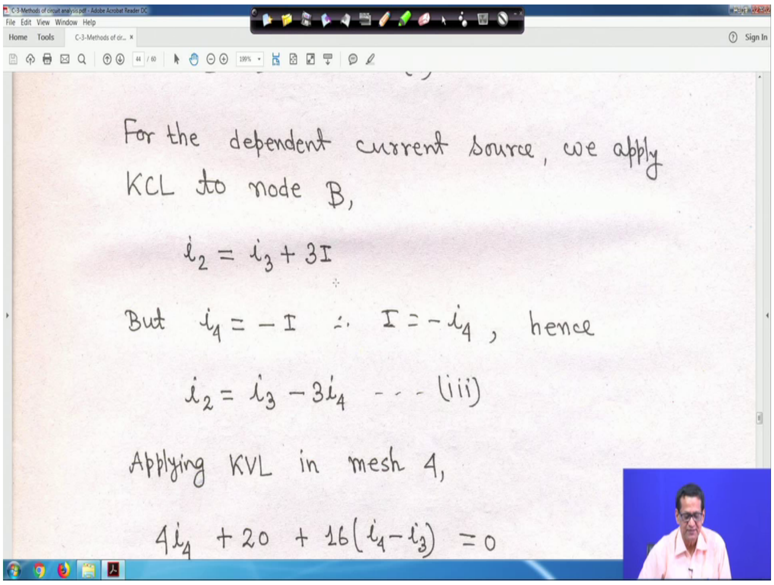

So, where it has gone here that i 2 is equal to i 3 plus 3 I, right.

Now, you have to see that what is your i 4 is equal to minus I. Next one is here if you come this is this direction, we have taken just hold on these direction these direction we have taken.

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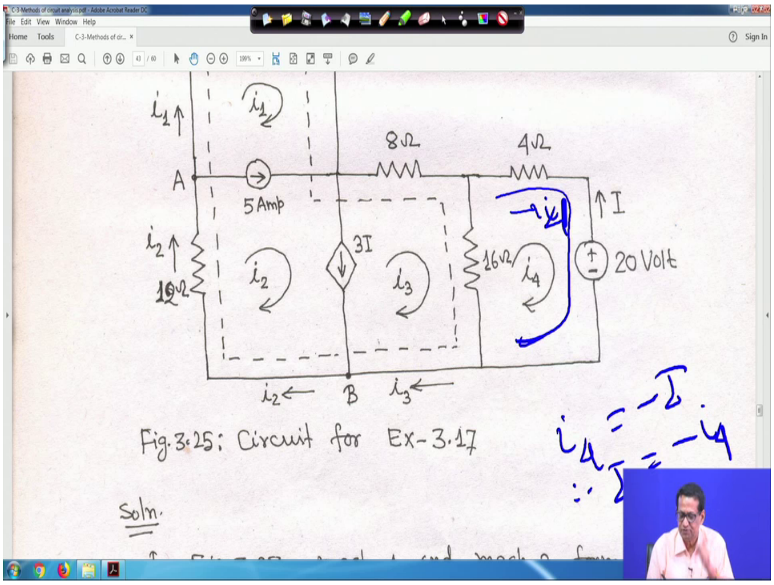

So, this is your i 4, but this I is taken upward it going like these. So, i 4 is equal to minus I or capital I is equal to minus i 4, right. So, let me let me clear it. So, so this one your this one I, then i 2 is equal to i 3 minus 3 i 4, right because just now just now, we have given that I is equal to minus i 4, this is equation 3. Now I apply KVL in mesh 4. If you apply KVL in mesh 4 in this mesh; that means, in this mesh if you apply KVL in this mesh if you apply, it will be 4 i 4 plus 20 right plus 16 into i 4 minus i 3.

So, let me clear it. So, directly I am not writing again, it is understandable to you, right.

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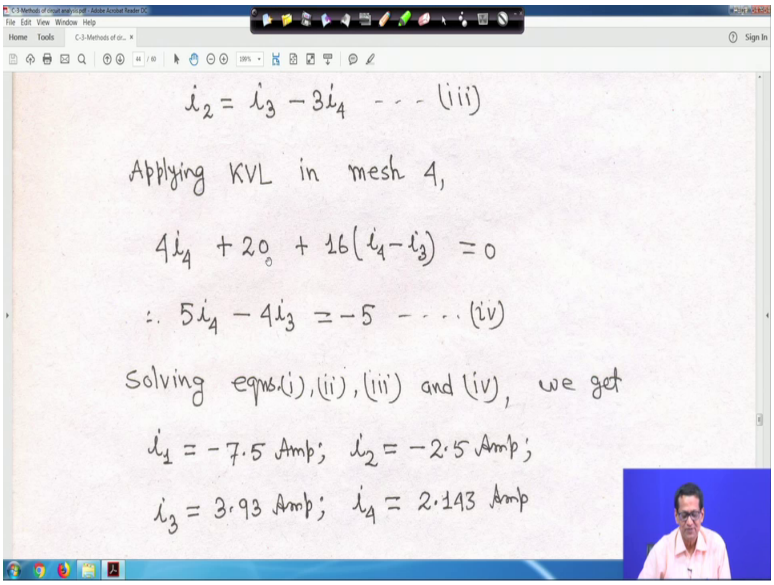

So, if you apply your this thing 4 i 4 plus 20 plus 16 into i 4 minus i 3. So, this is 5 i 4 minus 4 i 3 is equal to; so, equation 4. So, you have 4 equations and 4 unknown. So, after solving this, you will get i 1 is equal to minus 7.5 ampere, i 2 is equal to minus 2.5 ampere, i 3 is equal to 3.93 ampere, i 4 is equal to 2.14; 2.143 ampere. So, this is 4 unknown, but all 4 equations are simple one and I do believe that you have understood that because with the time we will progress.

So, initially everything I writing for you for your understanding and after that little bit, you also do, right and I believe all this answers everything computed here are correct and if by chance if you find any calculation and anything. So, just send me an email when you will read this your video lecture.

Thank you very much, we will be back again.