Basic Electrical Circuits
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Lecture – 60

So, far we studied mesh analysis for circuits containing only resistors and independent voltage sources. Now, we will consider other sources, firstly the independent current source and then, also the control sources.

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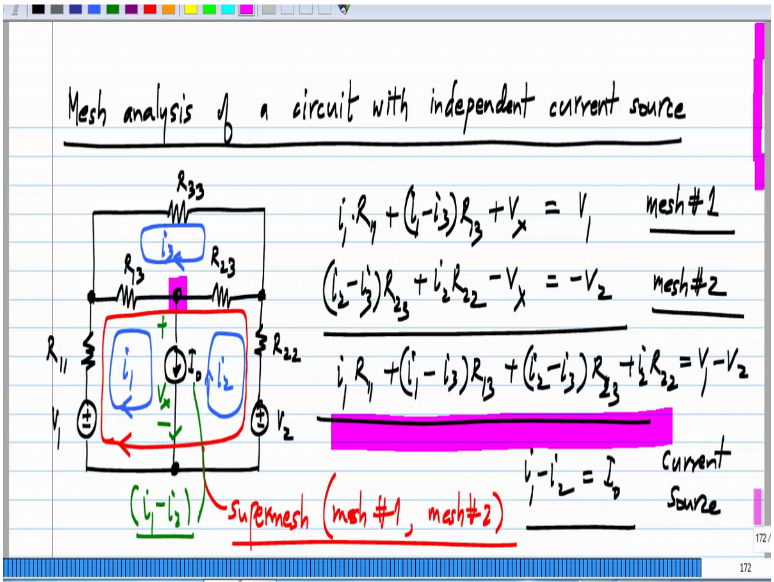

Let me take the circuit, where here I have an independent current source. You recognize that this is the same circuit we had earlier, except that I replace the resistor with an independent current source. Now, while writing mesh analysis equations we had the voltage drops around each mesh to be equal to the voltage rise due to the independent voltage source in the mesh. The problem with the current source is that, the voltage across the current source is unrelated to the current through the current source.

You cannot infer the voltage across the current source from the current through the current source and the whole purpose of the current source is to maintain constant current flow regardless of what voltages across it. This is analogous to the problem we had with nodal analysis, when we included independent voltage sources. And the solution is also similar to what we did with nodal analysis and independent voltage sources.

So, let me take the three meshes, the same as before with mesh currents i 1, i 2 and i 3 and the voltage across the current source, let me label that V x. Now if I write the KVL equation around the first mesh I will get i 1 times R 1 1 plus i 1 minus i 3 times R 1 3, which are the voltage drops across R 1 1 and R 1 3. I do not know the voltage drops across this current source, so I will just label that V x and that should be equal to the voltage rise V 1, so this for mesh number 1.

Now, for the second mesh I know that, i 2 minus i 3 times R 2 3 plus i 2 R 2 2 and I do not know the voltage drop across this and now I have to take it in the opposite direction, so I will get minus V x to be equal to minus V 2. The problem is this V x which we do not know and just like before, we sum the equations corresponding to these two meshes and we will get i 1, R 1 1 plus i 1 minus i 3 times R 1 3 plus i 2 minus i 3 times R 2 3 plus i 2 R 2 2 to be equal to V 1 minus V 2.

V x goes away, because in mesh number 1 it appears with one sign, in mesh number 2 it appears with the opposite sign. And now, what is this after all, this is basically the voltage drops if you go around this entire loop, which consists of these two meshes and this is known as the super mesh, which is the combination of mesh number 1 and mesh number 2. So, by forming a super mesh we can eliminate this problem of not knowing the voltage across this independent current source.

This is like forming a super node to not worrying about the current that is flowing the through the independent voltage source in nodal analysis. Of course, by combining two mesh equations into one we have lost equation, but we now also know by applying Kirchhoff current law here that i 1 minus i 2 equals i naught. Because, the current through this branch in the downwards direction is i 1 minus i 2, here it should be i 1 minus i 2, but I know that value, because the independent current source sets this current to be equal to i naught.

So, I have the equation for the current source itself and I get this equation and with these two equations and also for the third mesh, mesh number 3 I have the same equation as before. So, with these three equations I can solve for all three mesh currents and from there, get all the branch currents and branch voltages. So, when you have an independent current source, you form a super mesh and by doing that you lose one mesh equation, but you have the constraint corresponding to the current source itself, that gives you another equation with which we can complete the set of the equations required to solve for all the variables in the circuit.

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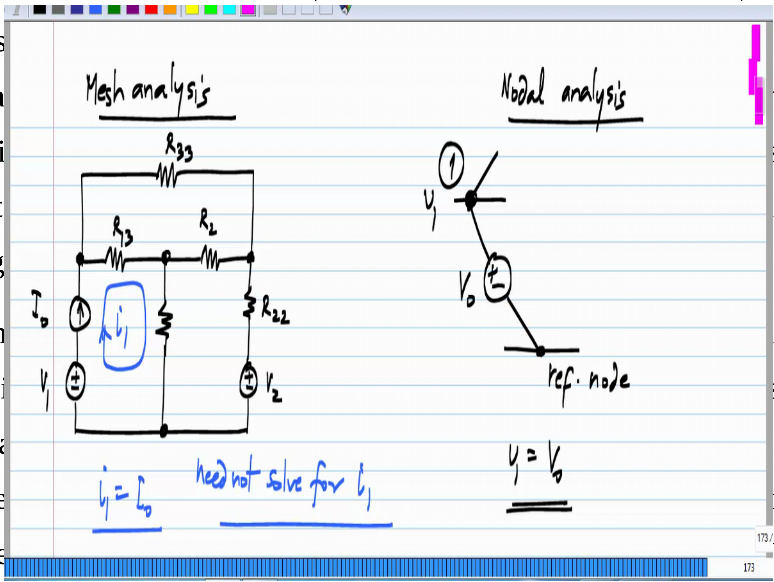
Now, we considered the current source, which was between two meshes, but let say there was a current s and this is not in a branch tha he periphery of the circuit, so i s even simpler, you know that that has to be equal to i naug



So, this straigh ve to solve for i 1, now this i s and in nodal analysis; let sa e between the reference node of other things could be conne V 1, you know V 1 implies V naught.

So, similarly the situation of having a current source on the periphery of the circuit is analogous to this, where you will not even have to solve for this one variable. So, the mesh analysis for planer circuits is analogous to nodal analysis in a lot of ways. The easiest case for nodal analysis is to have only resistors and independent current sources. The easiest case for mesh analysis is to have only resistors and independent voltage sources.

Now, in nodal analysis when you have an independent voltage source you have to form a super node by combining two nodes, in case of mesh analysis you have to form a super mesh by combining two meshes. Now I said the two, but the dependence on how the voltage sources are connected enough that in some cases if you have chain of voltage sources in nodal analysis you may have to combine more than two nodes in to super node.

Similarly, in mesh analysis also if you have a current source in many branches in circuit, you may have to form a super mesh, which is a combination of more than two meshes, so all of this is possible. And these situations are analogous; that is I am not considering them in great detail and I am going analytically quickly through them.

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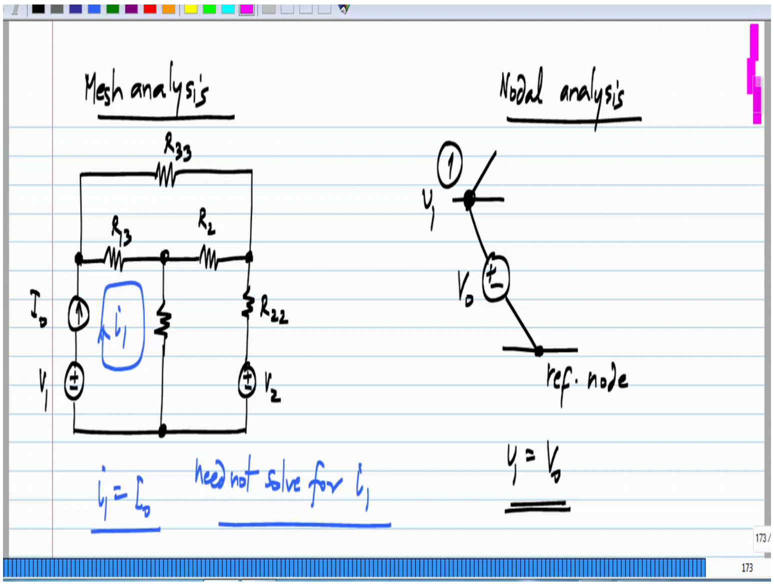

So, if you compare the two mesh analysis is a when you have circuit for the resistors and independent voltage source is and for nodal analysis that is for circuits with resistors and independent current sources. In these cases the structure also is similar we have the resistance matrix times the mesh current vector to be equal to the source vector consisting of independent voltage sources and in case of nodal analysis we had conductance matrix times in the node voltages vector equaling the independent current source vector.

Also these had similar structures there were symmetric and if you look at the diagonals in this case it was sum of conductance's at a node and in the case of mesh analysis it was some of resistances in a mesh and of diagonal elements were also similar in case of nodal analysis of diagonal element was the negative of the conducts between to particular nodes and similarly in mesh analysis it was the negative of the resistance common to two meshes.

When even to current sources with mesh analysis we have to form a super mesh and this is similar to having independent voltage sources with nodal analysis in which, case you have to farm a super node. So, with this analysis and the detail treatment of nodal analysis we have gone through we should also be able to do mesh analysis and understand it properties for all cases.