Basic Electrical Circuits
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Lecture – 42

In this unit we will look at nodal analysis, which is one of the systematic ways of analyzing circuits.

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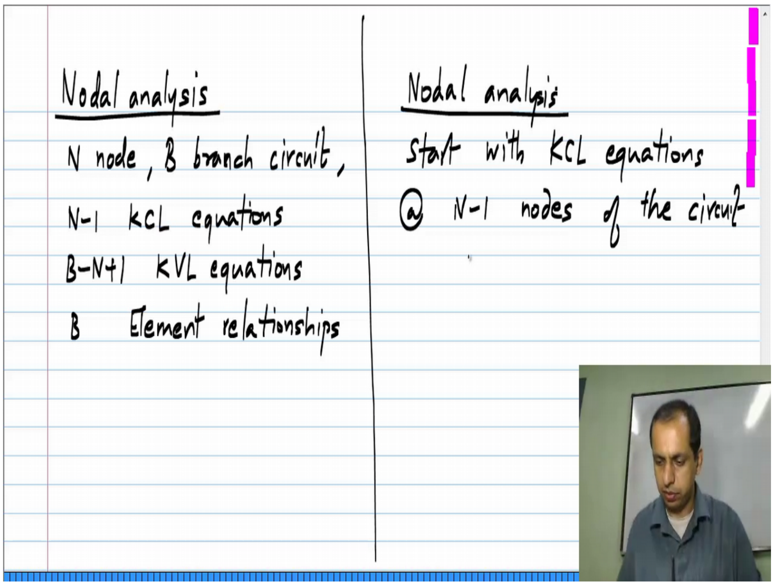

We have earlier seen that to solve for a circuit completely we need two B equations, where B is the number of branches and we have also seen that for an N node B branch circuit, we will write N minus 1 Kirchhoff's current law equations, B minus N plus 1 Kirchhoff's voltage law equations and B element relationships. We will consider two terminal elements, but these things can be generalized to larger number of terminals.

So, now, depending on which of these two you do first, whether you first write KCL equations or KVL equations, there are different types of analysis. If you start off with KCL equations at N minus 1 nodes of the circuit, it is known as nodal analysis and if you start with KVL equations around V minus N plus 1 loops of the circuit, it is known as loop analysis and a variant of that is called mesh analysis. We will see those things later, we will first consider nodal analysis.

So, you start with KCL equations at N minus 1 nodes of the circuit. It turns out that, this is the more difficult part and after this from the solution of this you can calculate everything and within this, you will be implicitly using Kirchhoff's voltage law as well. So, this is the significant part and from this to get all the branch voltages and currents, it turns out to be quite easy.

So, again what we are looking at here are systematic ways of analyzing circuits, which could be arbitrarily large. For examples of course, which will be done by hand calculations, we will consider small circuits, but exactly the same techniques can be scaled to very large circuits.

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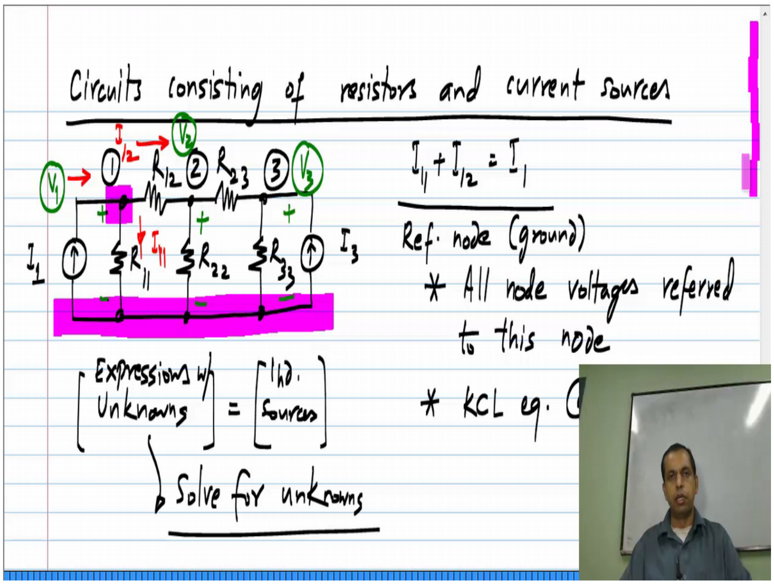

So, let me take some example and initially I will consider circuits consisting of resistors and independent current sources. It will later become clear why we start with this, this turns out to be the easiest case for nodal analysis. So, let me put down some circuit as an example to work with. So, I considered as a circuit with four nodes and a number of resistors and current sources and let me label these I 1, I 3, R 1 1, R 2 2, R 3 3, R 1 2 and R 2 3.

So, now, what do I write when I write KCL equations I will look at every node, there are four nodes here 1, 2, 3 and 4, I choose any three of the four nodes and write KCL equations at all those nodes. Now, I have to neglect, I have to omit one of the nodes while writing KCL equations and in this example, I will choose to omit this one and write KCL equations at these three nodes which I am going to label 1, 2 and 3.

Now, at every node I write the sum of currents going out of the node to be equal to the incoming current from the independent sources. So, the way we will setup all of our equations is like this. We will have some relationship between unknowns, some expressions containing unknowns and that will be equal to the independent sources, which are known and by solving for this we will solve for the unknowns.

So, what I mean is when I am writing down equations I will push the terms containing independent sources to the right hand side and retained the terms containing the unknowns the variables on the left hand side. Now, essentially what I have to write is for instance, I have to write that the current here, let me call it I 1 1 for now and current over there I 1 2 that has to be equal to the current coming in from the independent source.

So, essentially I have to write I 1 1 plus I 1 2 equals I 1. Now, I 1 1 and I 1 2 are currents through resistors, like I said we are looking at circuits with resistors and independent current sources and independent current sources appear on the right hand side. So, the left hand side all of them consists of currents through resistors. Now, I have to choose some variables to solve for, like I said while doing nodal analysis I will start off with KCL equations, but while writing down the terms of the equations I will be implicitly using Kirchhoff's voltage law as well as the element relationships, in this particular case the V I relationship of a resistor.

So, let me take this particular node and rewrite this I 1 1 in terms of the voltage across the resistor and the resistance value. Now, before setting down our nodal equations I have to choose some variables as the voltages which I will solve for and while writing down the equations for nodal analysis, I will choose the node voltages with respect to a common reference node as my variables. The reference node will be the one node at which I am not writing the KCL equation.

So, all node voltages referred to this node and you do not write the KCL equation at the reference node. In our particular circuits, this node at the bottom is the reference node and I have these three variables here V 1, V 2 and V 3, these are the voltages with respect to the reference node. When I say V 1 it is with respect to this one, it is the voltage between this node and this reference node, sometimes the reference node is also referred to as the ground node.

Similarly, V 2 is between node 2 and the reference node and V 3 is between the node 3 and the reference node. I will use these variables V 1, V 2 and V 3 as the primary variables and write down my equations.