Basic Electrical Circuits

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Lecture - 67
Splitting a current source

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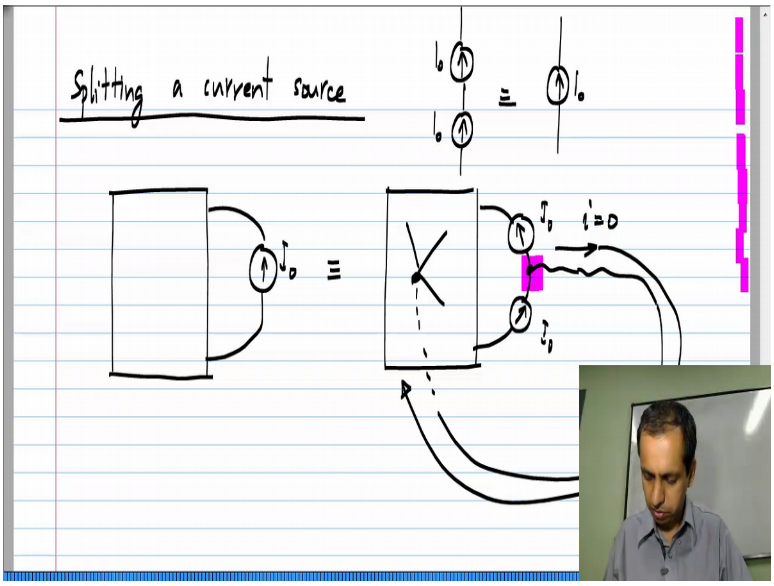

In this lesson, we will consider another elementary theorem, this time involving current sources. I will call that splitting a current source; it will be clear why it is called that way. Let say we have some circuit, it could be any circuit, and it has a current source. I am not imposed any restrictions on this circuit, it could be linear, non-linear whatever and it has this ideal current source connected somewhere. Let say the value is I naught. Now it is clear that this is exactly equivalent to two identical current sources in series. In fact we cannot in general connect current sources in series except when they have identical values; and if they have identical values, then the series combination is equivalent to a single current source that is if you have two currents of I naught in series is exactly equivalent to having a single source also I naught in series.

Now what is the point of this, if you consider this middle node then the current coming from here is I naught and the current going there is I naught. And even if you have a wire that is going elsewhere, let say this connected the current in that will be a exactly equal to zero because of Kirchhoff's current law, because this is I naught that is I naught that has to be 0. So, now, combine this with the fact that an ideal current source will provide the same current regardless of what voltage is across it. We can connect this to any other node in this circuit. Let say we have some node here, we can connect it, because this current is 0; imagine that this is a node with the number of connections and before making this connection the sum of all those currents will be zero, and this is just adding zero current. So, this is really not contributing anything at all to the Kirchhoff's current law equation at that node. So, you can make this connection without disturbing the rest of the circuit.

So, to summarize, if I have an ideal current source in a circuit, I can think of it has two ideal current sources of identical values in series, and the midpoint can be connected to any node in the circuit because that carries zero current, these two currents are exactly equal to each other. So, it has to carry zero current. So, it would not disturb any of the other nodes in the circuit, and these current sources can work with any voltage across them that is the meaning of an ideal current source. So, if you connect this to some other node and change the voltage across the current source nothing happens. So, this is known as splitting the current source, when you can have an ideal current source you can imagine that as being two identical current sources in series and connect the mid point to any point in the circuit.

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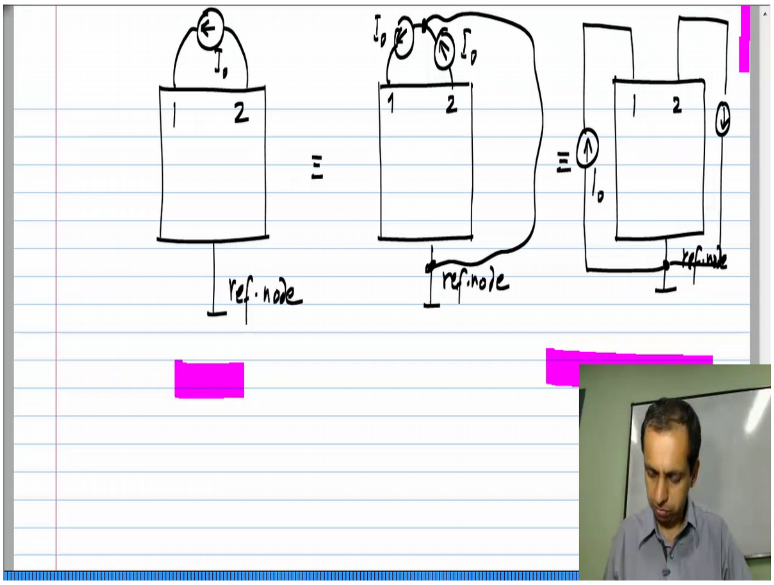

Now, what is the use of this, so let say we have a circuit and there is some node we think of as the reference node. Now I have a current source like this, and I will split it into two sources in series. Now I can connect this to any node and let say I choose to connect it to the reference node. So, then I redraw this circuit as this one I will say this was point 1 and point 2. So, from point 1, we have a current source going to the reference node of value I naught; all these are of value I naught by the way. And from point 2, we have another current source also going to the reference node. Now what is the difference between this and that.

In this, we have a current source between some two nodes of the circuit neither of which is the reference node. In this, we have two current sources, but these current sources, but these current sources have one of the terminals connected to the reference node. Now it turns out that in many cases it is easier to analyze circuits, when the source is connected to the reference node. Now we would not be able to appreciate it without any examples, but just take it from me that many times it easier to analyze circuit likes this, so that is why this was splitting the current sources helpful.

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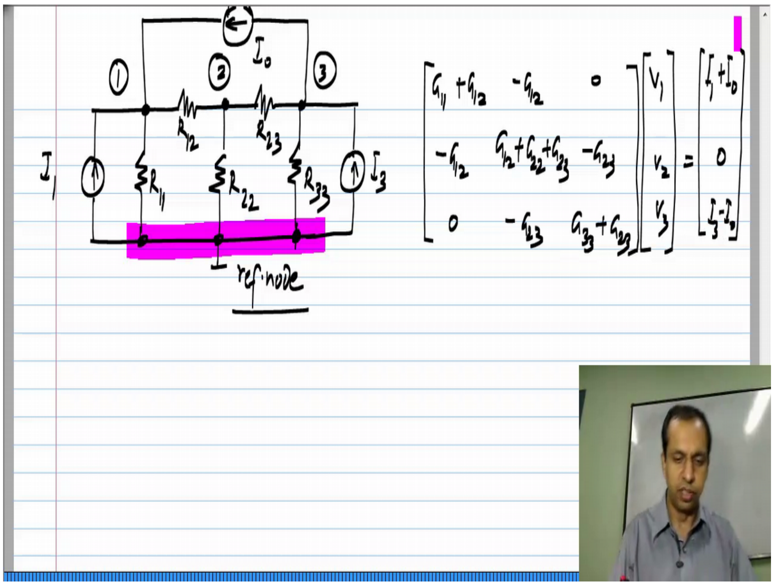

Just to illustrate this point. Let me take the example, I had taken long back while discussing nodal analysis. I had I 1, I 3 and R 1 1, R 1 2, R 2 2, R 2 3, R 3 3. Now I had discussed circuits like this, if it is not exactly this one. Let say I have this current source I call this floating current source if neither of its terminal is connected to the reference node the reference node is over here. Now please pause out this point, and write down the nodal equations. I am going into write it as well and you can compare the results, just for extra practice. So, if I do that I will have that mean number the nodes like this 1, 2 and 3; I will have G 1 1 plus G 1 2 minus G 1 2 0 minus G 1 2 G 1 2 plus G 2 2 plus G 2 3 minus G 2 3 0 minus G 2 3 and G 3 3 plus G 2 3 times V 1 V 2 V 3 equals total current pushing into node 1, which I 1 plus I naught, total current pushing into node 2 which is 0, total current pushing into node 3 which is I 3 minus I naught. Now let me do the current source splitting business on this circuit.

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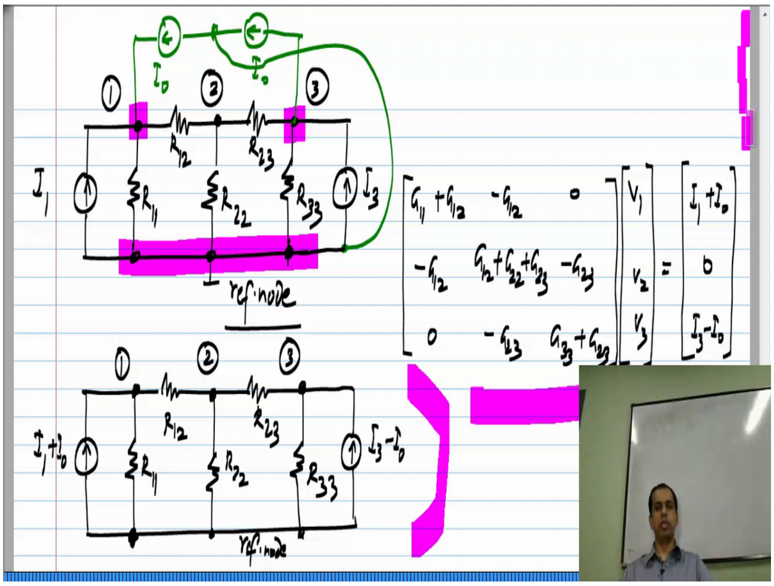

Now, let me carry out the splitting of current source business on this circuit. I will erase this and connect two identical current sources in series I naught and I naught. And this middle node, I connect to the reference node. I said this is the useful part. Now you see that this current source is between this node and the reference node therefore it is in parallel with this one. So, what will have is I 1 plus I 0, this is between node 3 and the reference node and it is in opposite direction to I 3. So, on this side will have I 3 minus I naught. And the rest of the circuit is as before. Now the conductance in the circuit have not changed at all; they have exactly the same arrangement as before, this is node 1, 2, 3 and the reference node. So, the conductance matrix basically the left hand side was the equation remains the same. I will copy it to over from the previous case the only thing that I have changed are the current sources.

Now, here I have two current sources instead of 3, but in the first row of this right hand side vector, I have to have the total current source pushing into node 1 which is I 1 plus I 0; and for node 2, it is 0; and for node 3, it is the total current ppushing into node 3, which is I 3 minus I 0. If you go back here, you see that it is exactly the same set of equations we have got. So, clearly the solution to this circuit with split current sources and the split point connected to another node will be exactly the same as for the original circuit because the equations are the same so that illustrates my point that when you have a current source connected between any two nodes, you can think of it has a series combination of two current sources and connect the midpoint of those to any other node in the circuit without altering the solution. Now in this case, I tied it to the reference node usually that is what we will do to make our circuit analysis easy, but it could be tie to any other node; in fact. you can try it with this circuit also you can tie it to any other node and the equations will remain exactly the same, which means if the solutions will remain the same and nothing has changed in the circuit.