Basic Electrical Circuits
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Lecture – 39

Analysis of circuit with Multiple Independent sources using Superposition

We have discussed what is to be done in circuit analysis. If you have a circuit with N nodes and B branches, we need to solve for two B variables, which consist of B voltages and currents in the B branches. Now, we saw that when the circuit has a single independent source, we do not have to resort formal analysis, we can use series and parallel combinations of resistances to come up with a solution. Now, we look at another method that is used before going on to formal circuit analysis. Now, this is known as using the principle of superposition to solve for circuits containing more than one independent source. Now, we have not yet proved the principle of superposition yet, now that will be very easy to do after we discuss a formal methods of circuit analysis, but for now we will take it for granted and use the principle of superposition when we have more than one independent source.

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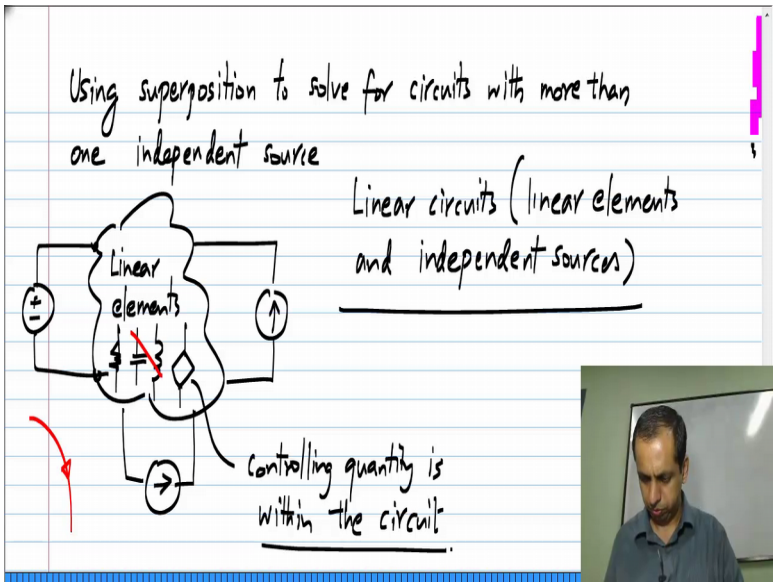

Now it turns out that when you have a circuit with multiple independent sources. Let me show the circuits like this; I will show all the independent sources outside and within the body of the circuit we will assume we will have only linear elements. Now linear elements are resistor, capacitor, inductor, and also controlled sources. Now in the initial

part of the course, we will be looking at circuits without inductors and capacitors that is circuits without energy storage elements. So, even these would not be there. So, essentially we will be discussing circuits with resistors and controlled sources. So, everything is enclosed in this except for independent sources. And of course, the condition is also that for these controlled sources for these linear controlled sources, the controlling quantity is within the circuit, this controlled quantity could be dependent on some voltage within the circuit or some current within the circuit. So, we cannot define let say some other current flowing elsewhere outside the circuit and make these controlled source dependent on that. So controlling quantity is within the circuit. Now because these are all linear elements, it turns out that we can use the principle of superposition. So, we will call these linear circuits; obviously, it means a circuit that consists of linear elements and independent sources.

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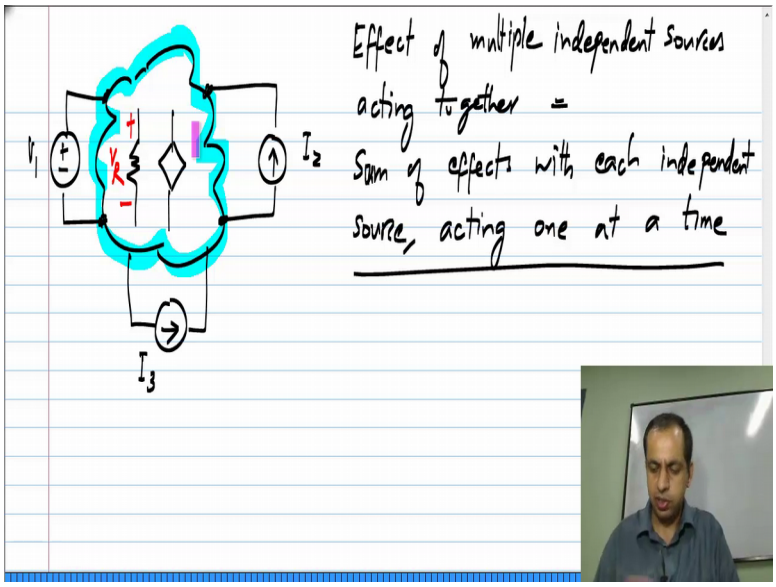

So, when we have such a circuit, let me take that example again. First I will not worry about what in this circuit except to say that it consists of linear elements, and I will show independent sources like this. So, as I said earlier what is inside, inside this box those elements are all linear, and we know that these independent sources are not linear, we have discussed this earlier in the first unit that the V I characteristics of these do not pass through the origin, they do not obey superposition, but what is inside this box they are resistors and linear controlled sources, so they are linear. And let me label these V 1, I 2, I 3. Now we have to be calculating for something in the circuit. So, I will highlight a particular voltage, so let say the voltage across this resistor.

Now, what does the principle of superposition say the effect of multiple independent sources acting together equals the sum of effects with each independent source, acting one at a time. We will elaborate on what this means, in this particular circuit, there are three independent sources, what this is saying is this V R - the voltage across the resistor due to the three independent sources can be calculated by taking one independent source at a time, calculating a value of V R for each case and summing the values together. So, that is all that is there to it so that is what superposition is.

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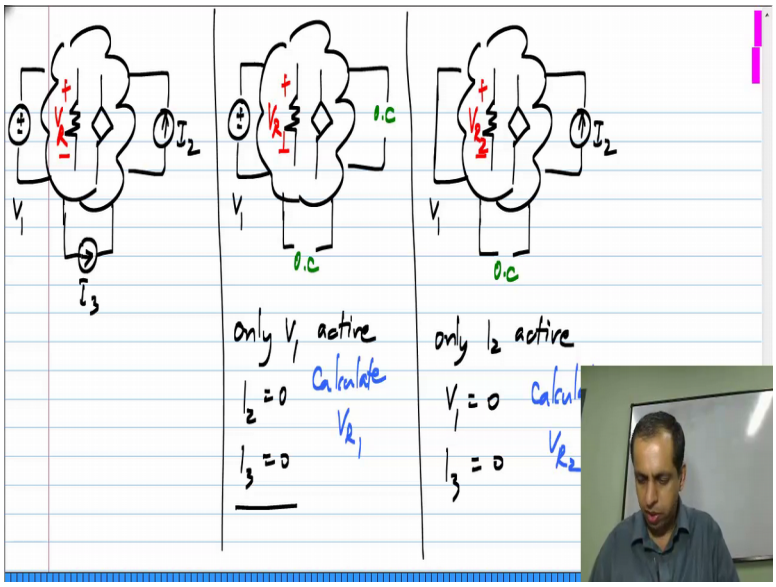

In other words, I have some V R here. So, instead of analyzing the circuit with three independent sources together, what I do instead is first analyze the circuit with only V 1 being active. Now what does this mean, this means that I set I 2 to 0, and I 3 to 0. So, what does it mean to set a current source to 0, when a current source is 0, we know that it is an open circuit. We have discussed this earlier as well a zero valued current source is an open circuit because that means, that no current flows between these two along this path. So, basically I have replaced them with open circuits. So, let me mark that here just for clarity so this is an open circuit and this is open circuit.

Let me call the voltage V R I get from this as V R 1. So, what I do is the following I set I 2 and I 3 to 0. So, I have now a circuit for the single source, and we know that this is quite easy to analyze and from this I calculate the voltage across the resistor or whatever quantity I want; if I wanted current through this source, I could calculate that I am taking the resistor voltage as an example, so I do this. Next I analyze the circuit once again, this time I will have only I 2 to be active so that means, that V 1 is 0, and I 3 is 0. So, what do

I do, I have to set I 3 to 0, a zero valued current source is nothing but an open circuit so that is what I do I open circuit the current source. And I have to set V 1 to zero, a zero valued voltage sources is a short circuit, because between these two nodes you have zero volts so that means that we have a short circuit. And I get a certain value of the resistor voltage from this and let me call that V R 2, so I calculate V R 2.

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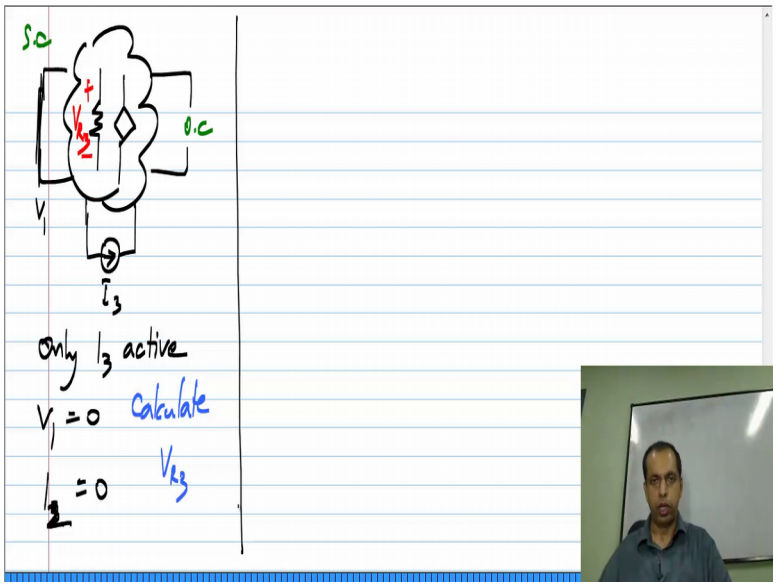

Finally, I do the analysis a third time; and this time, I will have only I 3 active, which means that I set V 1 to 0 and I 2 to 0. So, if I set I 2 to 0, a zero valued current source, we know by now is an open circuit and a zero valued voltage source is a short circuit. This is a short circuit and value of V R, I get in this particular case, let me denote that by V R 3. So in this case I calculate V R 3. So, there were three independent sources, I would do the analysis three times each time I keep only one of the sources to be non zero, and all the remaining ones to be 0. Now what does it mean for voltage sources setting them to zero means replacing them by a short circuit; for current sources setting them to zero means replacing them by an open circuit.

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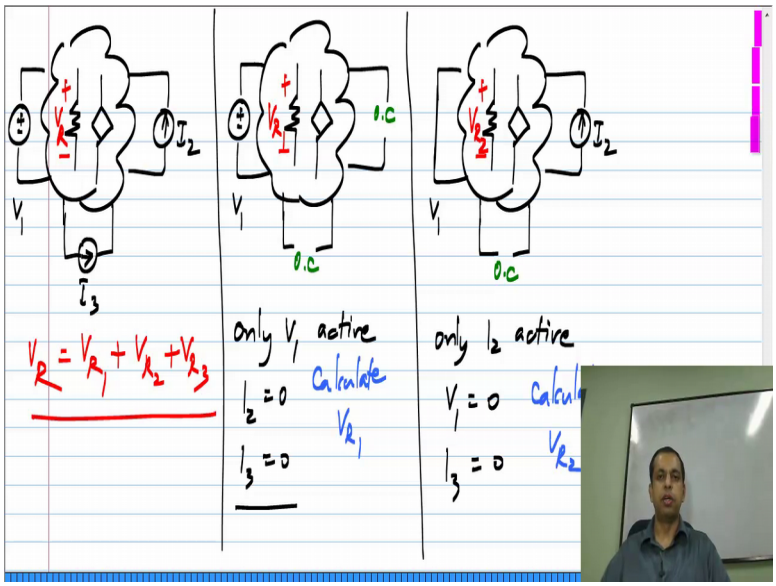

Then for the full solution V R, I sum the three individual solution V R 1 plus V R 2 plus V R 3. So, this is how I can get the solution to the circuit which contains three independent sources. Now instead of analyzing one circuit we did it three times, but each time with the single source, so that is why it is easy to do; with the single source it is always easy. So, we do it three times and sum the results together. Now a couple of points I wish to make; first of all sometimes when this is stated a student think of it as having only one source and removing others and so on. It is best to avoid such imprecise terminology as removing sources etcetera. What we are doing is having only one of the sources to be non zero and setting all the other sources to zero, and that makes it very clear that a current source should be replaced by an open circuit, because zero current and a voltage source should be replaced by a short circuit because of zero voltage so that is one thing.

The second thing is let say you have a certain electrical quantity you like the voltage across the resistor V R defined here, make sure that you would take it in the same polarity in the same direction, in every one of the analysis. In this particular case, the upper node is defined to be positive and the lower node is defined to be negative in the definition of V R and that has to be preserved through all the three analysis. And in individual analysis V R could come out negative or positive whatever it comes out you take it and then take the algebra is some of all the results to arrive at the final answer.