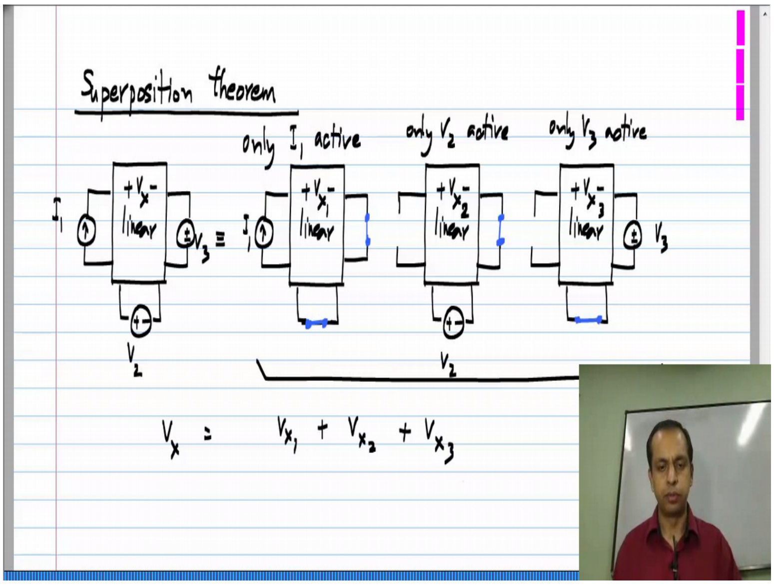
Basic Electrical Circuits

Dr Nagendra Krishnapura
Department of Electrical Engineering
Indian Institute of Technology Madras

Lecture - 72

We have earlier looked at the superposition theorem and the substitution theorem. Now, I will consider minor extensions to these.

(Refer Slide Time: 00:13)

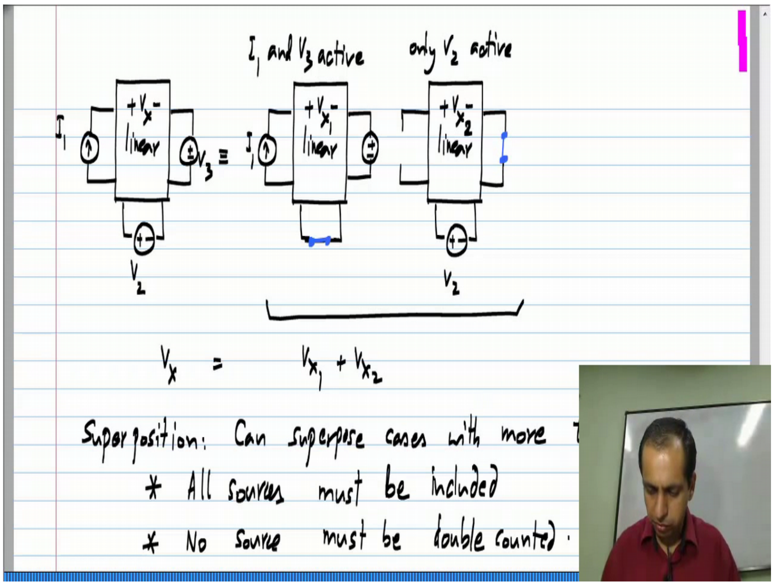


Now, these extensions may seem trivial, but we will be using them to prove other theorems, so that is why I am going to explicitly mention them. Now, when I discuss superposition theorem I said that, if you have a circuit with the number of independent sources and the rest of the components are linear, that is the resistors and control sources. You can find the response that is, the voltage or current anywhere in the circuit by considering one source at a time.

Now, in the very minor extension I have is the following. I do not have to take one source at a time, I can take multiple sources at a time and while doing so, over all the cases that I consider, I should not be double counting any source and I should be completely covering all the sources that is all, that also gives you the solution. It is easier to discuss this with specific example, with specific number of sources, so that is what I am going to do.

So, let us say this is the linear part of the circuit that is, it has resistors and linear control sources and there are three independent sources, just for simplicity sake I will considered this. What I had said earlier was, let us say I have to measure V x somewhere in the circuit, then I will think of it as some of these three cases, a first one in which only the current sources active. So, let say a label is V 1, V 2 and V 3. So, the first one is with only I 1 active and the second one is with only V 2 active and the third one is with only V 3 active. I measure V x with each of these cases, I could level this V x 1, V x 2 and V x 3. It is the same place that I measure V x, it is across the same branch, let say or between the same two nodes. Then, I will superpose these cases and find the solution V x is V x 1 plus V x 2 plus V x 3.

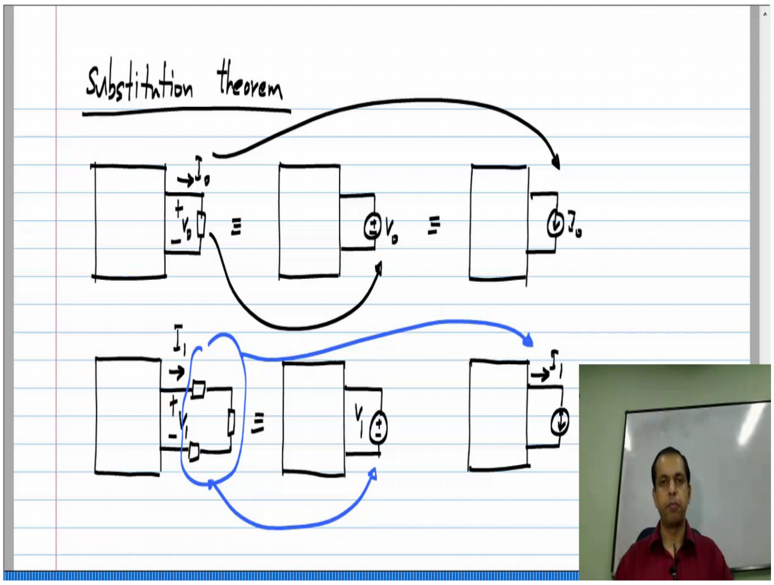
(Refer Slide Time: 03:11)



On the very minor extension I mentioned is this, I do not have to take one independent source at a time, I could take multiple sources. For instance, here I think of this case as super position of two cases, one in which I 1 and V 3 are active and the other one in which only V 2 is active. So, the only thing I have to ensure is that, over all the cases I consider first of all I take all the sources, all of them must be occurring once and exactly once, I should not be double counting any of them either.

So, here I 1 and V 3 are considered in this case and V 2 is considered in that case, so this is fine. So, I could superpose just these two cases and V x will be equal to V x 1, obtained when I 1 and V 3 are active plus V x 2 which is obtained when V 2 is active. So, that is all I wanted to extend the previous case 2. The important points as I mentioned earlier, all sources must be included and no source must be double counted. So, that is all, this is quite obvious and you will probably realize that this is true, but I explicitly mentioned it any way.

(Refer Slide Time: 05:19)



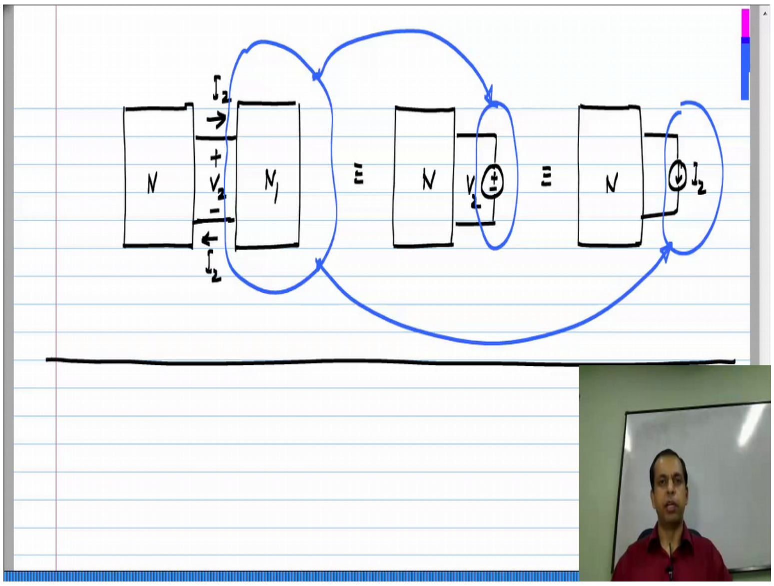
Now, let us consider substitution theorem. So, here again I said that if I have any circuit, in this case it does not matter whether it is linear, non-linear or whatever it is and under certain conditions I give an element, it could be a resistor, it could be something else also. It has a certain voltage V naught across it and certain current I naught through it, it applies only for this specific conditions of voltage values and so on.

This can be thought of us being equivalent to, the voltages and currents in this will be exactly the same as if the element is replaced by a voltage source V naught and also equivalent to if the element was replaced by a current source I naught, whatever voltage was across this, you can replace that with the voltage source of that value, whatever current is flowing through that you can replace it with the current source of that value, this is the substitution theorem.

Now, the very minor extension I mention is that you do not have to have just one element for it to be substituted, you can have multiple elements. So, for instance, so let say we had a series combination of three elements and across the series combination, I had a voltage V 1 just to distinguish from the other case I will call it V 1 and through the series combination I had a current I 1. Now, this is exactly equivalent to, I can replace all these three together with a voltage source of value V 1.

So, I am replacing this whole series combination with that or I could also replace the series combination with the current source of value I 1. So, this is the extension, what do you substitute does not have to be a single component that is the point I am trying to make here.

(Refer Slide Time: 08:19)



Now, extending this further, let say I had two circuits connected together like this, this circuit I call N and this circuit I call N 1 and they are connected only at two points, that is it. There is no other connection elsewhere in the circuit for this or that one, inside there may be lots of components, but this circuit and that circuit are connected only at these two points and it turns out that, the voltage across this is let say V 2 and the current going that way is I 2.

Now, because this is connected only at these two points, applying Kirchhoff's current law for this entire surface enclosing N 1, we see that the current coming back that way also has to be I 2. Now, what I can do is, I can substitute this entire network N 1 with the voltage source of value V 2 or with I current source of value I 2. So, this thing here is a substitution for this entire network N 1, similarly this one here is a substitution for the entire network N 1. So, that is the minor extension to the substitution theorem.