Basic Electrical Circuits
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Lecture - 15
Voltage Sources in Series

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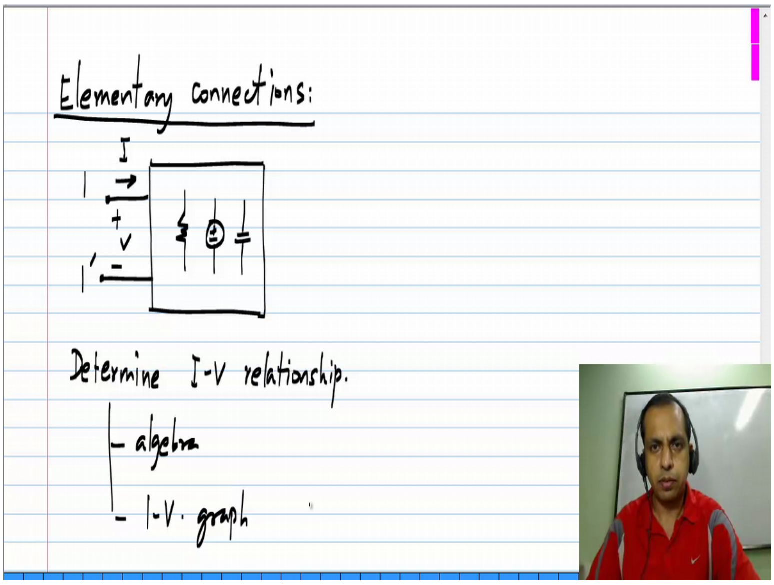

Hello and welcome to another unit of Basic Electrical Circuits. In the previous unit, we have looked at certain two terminal elements; in this unit, we will look at certain elementary combination of these elements, and see how they behave. And when I say how that behave what I mean is what the equivalent characteristics of the combination is that is you could have a network consisting of number of elements, but let say only two terminals are exposed to the outside world; and inside we could have many number of elements any element we want. Now if you are only allowed to connect to these two terminals this whole thing is effectively two terminal element with some characteristics. To determine what the characteristics are we have to find the relationship between the voltage across these two terminals and the current which goes into the terminal.

So, we need to determine the I V relationship and this could be either by algebra or graphically, they are just equivalent descriptions of the same thing. For single element, we saw that we could either specify algebraically such as ohms law. When we say v equals I R or we could draw starlight line in the I V plane with the slope of 1 over R; both of these correspond to a resistors. Sometimes one is more convenient than the other and we are going to use that one.

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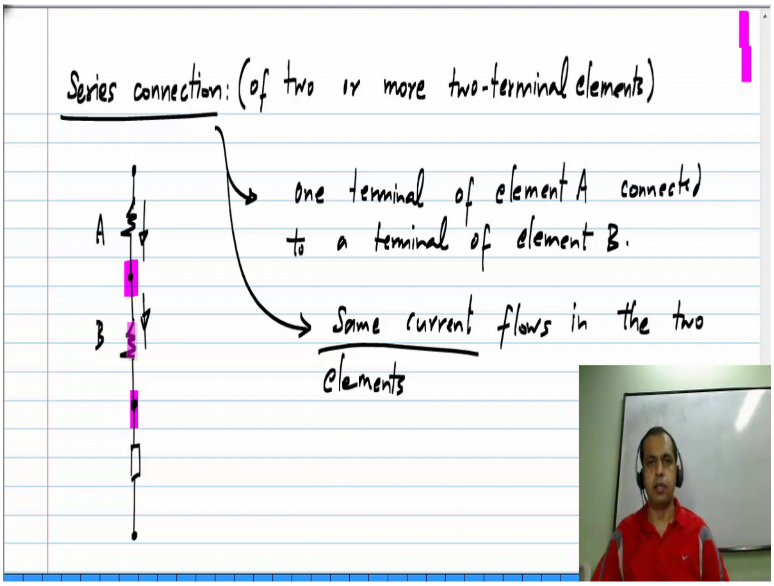

So, first let us look at what is known as a series connection. So, this refers to series connection of two or more two terminal elements. So, for instance, we could have one resistance and another resistance and connect the main series. Now what constitute the series connection for two terminal elements then one terminal of element A connected to a terminal of the second element - element B; or basically now the important condition is that there should be connected such that the same current flows in the two elements meaning there is a node which is common to the terminals of the first element and the second element and nothing else is connected to this node. So, this means that by Kirchhoff current law whatever current as flowing in element A will also flow in element B, because they are connected to the same node and nothing else is connected to it. So, this is known as series connection, the important proprieties that same current flows through them.

Now, you could have a number of elements in series one of another. The point is again each node will have two elements connected to it and nothing else connected to it. So, the current in this element will be exactly the same as the current in the other element; this is enforced by Kirchhoff's current law this is nothing to do with what elements we connected. Now next what will do is we will take the different elements that we know one by one and see what happened when they are connected in series. Now, I just said that when you have a number of elements in series the same current flows through all of them.

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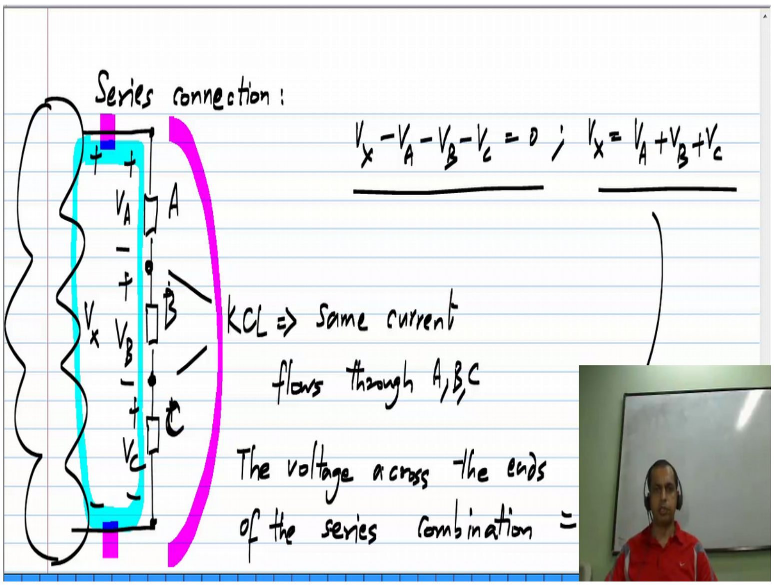

Because of KCL of at these nodes implies that the same current flows through all of them and also one thing you notice is that if you form a loop with something connected to this, does not matter what it is, and you denote this voltage across A by V A, voltage across the element B by V B, and this is the element C this by V C. And let say we denote the voltage between the upper and lower terminals by V x then we can right the Kirchhoff voltage law equation around this loop as V X minus V A minus V B minus V C equal 0, or V X equals V A plus V B plus V C; obviously, this means that the voltage across the ends of the series combination, by series combination, I refer to this whole thing here equals the sum of individual voltages. So this then is the definition of series connection, the same current flows through all the elements and the net voltage between the ends of that series combination is the sum of the individual voltages across the elements.

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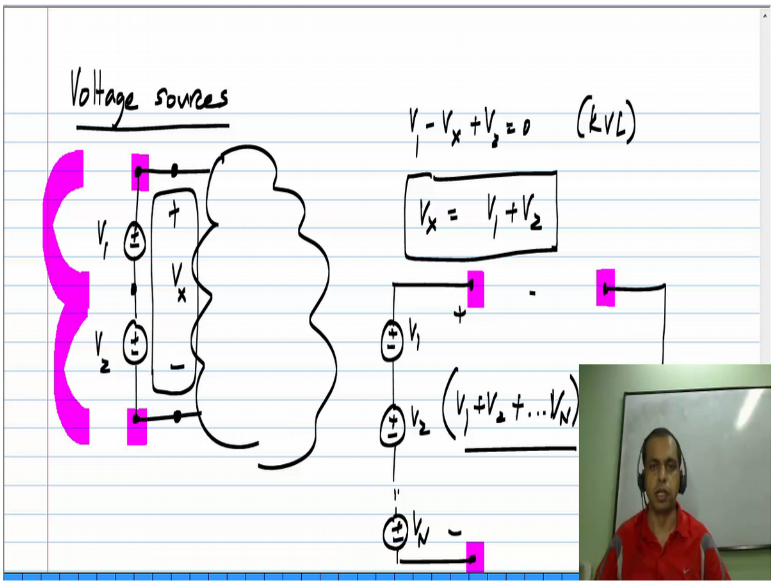

So, first let us take the elements in the same model of that we discussed them. Let us take two voltage sources in series. Let say this has a voltage of V 1, and this has a voltage of V 2 and obviously, we are looking at what it looks like between these two highlighted terminals. Now, I will go through it perhaps more elaborately then necessary, because this is the first time we are discussing it; I think all of you know the answer to this particular of thing already. Let us imagine that it is connected to something; it does not matter what it is. And by applying Kirchhoff voltage law around this loop, so if you call this V X between the upper terminal and the lower most terminal will clearly see that V 1 minus V X plus V 2 equal 0, because of Kirchhoff's voltage law. So, V X has to be equal to V 1 plus V 2. So, this is the very elementary use of Kirchhoff voltage law; it says that if you have two voltages in series, the resulting voltage between this terminal and that terminal is the sum of the voltages.

So, in general, if you have a number of voltage sources in series V 1 V 2 and I will show it all the way to V N, the net voltage as V 1 plus V 2plus all the way to V N. So, a series connection voltage sources behaves like an equivalent voltage source, because we see that this V X here is a fixed value, it does not depend on the current, so V X is V 1 plus V 2. So, if we have a number of voltage sources in series, the result is also an independent voltage source, and the value of voltage sources sum of all the individual voltage source values. So, it must be pretty obvious, this whole thing between these terminals is equivalent to single voltage source V X, whose value is given by this summation. So, what have we learnt so far, a series combination of voltage sources behave as voltage source and value of the voltage sources is the sum of the individual voltage sources; of course, you have to sum the voltages in the appropriate polarity.