Basic Electrical Circuits
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Lecturer - 21
Voltage Controlled Voltage Source

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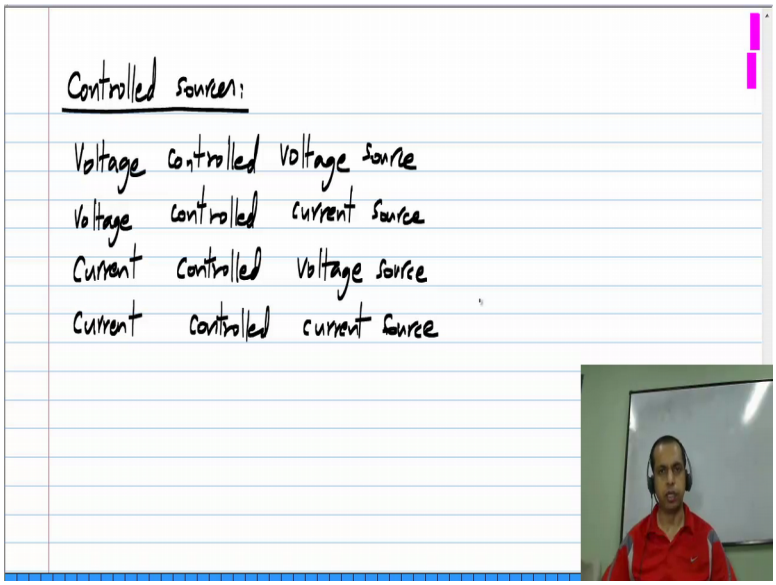

In this unit, we will look at controlled sources. Now so far we are discussed elements like a voltage and current source and basic elements like resistor, capacitor and inductor, these controlled sources are also elements which we will see in many circuits. So, unlike a resistor, they do not correspond to some physical entity, but they are most often used as models for abstracting the behavior of more complicated circuits. So, they are very useful in circuit analysis and circuit design. For instance an amplifier which is used quite commonly can be thought of as a controlled source, it is controlled by the speaker's voice or the output from the micro phone, and it controls the output that drives the speaker.

If you recall a resistor is an element, which enforces a particular relationship the voltage between two terminals and the current going through those terminals and that relationship is given by ohms law that is a linear resistor. Now when I said controlled sources, the control sources in general can be linear or non-linear, but here we will consider only linear controlled sources. Now controlled sources also enforce a similar relationship, but between quantities present that different pairs of terminals. Now

depending on which quantities controlling and which quantities controlled, we can have four different kinds of controlled sources, a voltage controlled voltage source, where a voltage between a certain pair of terminals controls voltage between another pair of terminals.

Similarly, we can have a voltage controlled current source, where a voltage between a pair of terminals controls the current flowing between another pair of terminals. And similarly, we can have a current controlled voltage source, where a current flowing in certain branch usually assume to be a short circuit controls the voltage between a pair of terminals. And finally, a current controlled current source, where a current flowing through a certain branch again usually assume to be a short circuit controls the current between a certain pair of terminals. We will take these controlled sources one by one and see how they behave.

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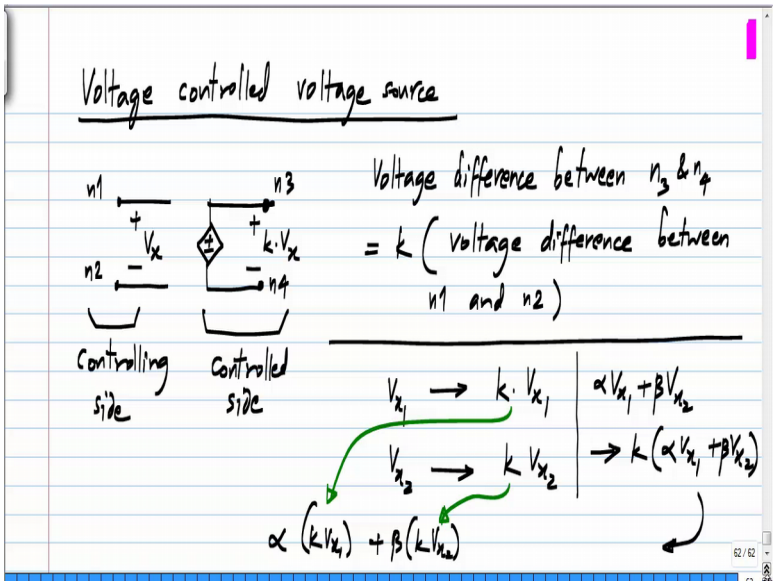

First, we will take voltage controlled voltage source; this is denoted by this particular symbol. Now independent voltage and current sources are denoted by a circular symbol to distinguish the controlled sources from them a diamond symbol is used. So, what this means is that these are the controlling nodes, and let us say the voltage between these two is V x , which is the controlling side, and this is the controlled side; and voltage between these two is given by some k times V x . So, this k is the property of the voltage controlled voltage source. So, if I label these nodes n 1, n 2, n 3, and n 4 what this says is voltage difference between n 3 and n 4 equals k times the voltage difference between n 1 and n 2, so that is the meaning of these symbol.

Now, first of all why is this linear, let say V x 1 is the controlling voltage, this results in a controlled voltage, which is k times V x 1; and V x 2 is the controlling voltage, it results in a control voltage k times V x 2. Now let say the controlling voltage is the alpha times V x 1 plus beta times V x 2; obviously which results in a controlled voltage which is k times alpha V x 1 plus beta V x 2 which obviously can be written as alpha times k V x 1 which you see is the voltage in the first case plus beta times k V x 2, which you see is the voltage in the second case. Linear combination of the cause gives you the same linear combination of the result. So, this is the linear element. And this must be pretty obvious from the relationship itself, because k times V x is a linear function of V x.

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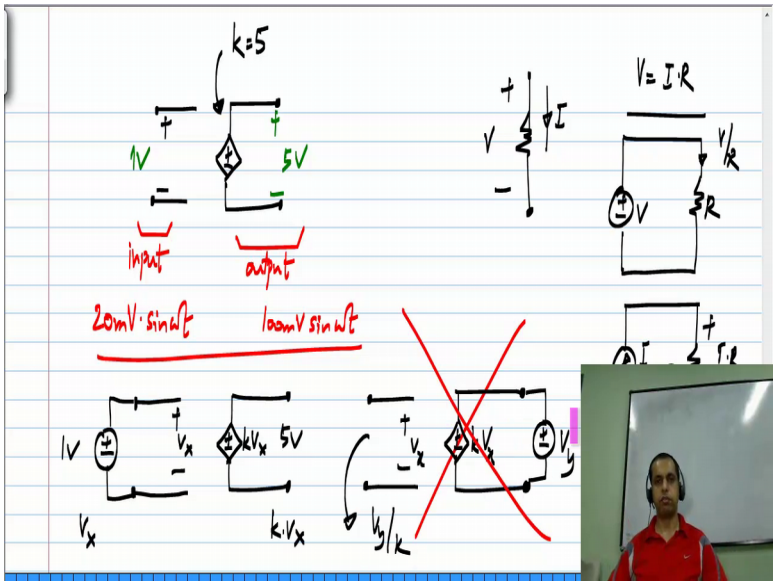

As far as this course is concerned it is about a circuit analysis; so, some circuits will have these controlled sources and you have to analyze the circuits with them in place. So, you apply these element relationships the one for the voltage controlled voltage sources I have already given and you will able to analyze the circuit. So, what does this do for instance, if we have a voltage controlled voltage source, and between these if I have let say one volt and let say for this voltage controlled voltage source k is 5 then between these two, I will have 5 volts. Similarly, if I apply an input, you can think of this side as the input, and this is the output. If I have let say 20 milli volt sine omega t apply to this side; on this side, I will get five times that which is 100 milli volts sine omega t.

So, voltage controlled voltage source is the sort of an amplifier, in fact it will be used as a model for an amplifier. Now one point I want emphasis about this controlled source as well as the others is that they are unilateral that is you take a resistor, it has this

relationship V equal I R, which can be interpreted both as applying a voltage V which results in a current V by R or applying a current I which results in a voltage I times R across the resistor. So, both ways are possible, but for a controlled source that not the case.

You can apply one volt on this side and get five volts on that side. So, in general, you apply V x on this side and get k times V x on the other side, this is the controlled source, but the other way around, you cannot apply a voltage to this side. So, let say V y the controlled volt source still is assumed to follows same relationship V x and k times V x, you cannot apply a voltage to the right side, and get V x equals V by k on this side. So, this is simply meaningless. Now this is the voltage source, you cannot apply another voltage source across it; we know that parallel connection of voltage sources is not valid. So, in a controlled source, the control flow only one direction - from the controlling side to the control side, it is called unilateral element. I cannot apply in input to the control side and expect some corresponding output from the controlling side. So, this kind of thing is just not possible.