Basic Electrical Circuits
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Lecturer - 25
Realizing a Resistance Using a VCCS or CCCS

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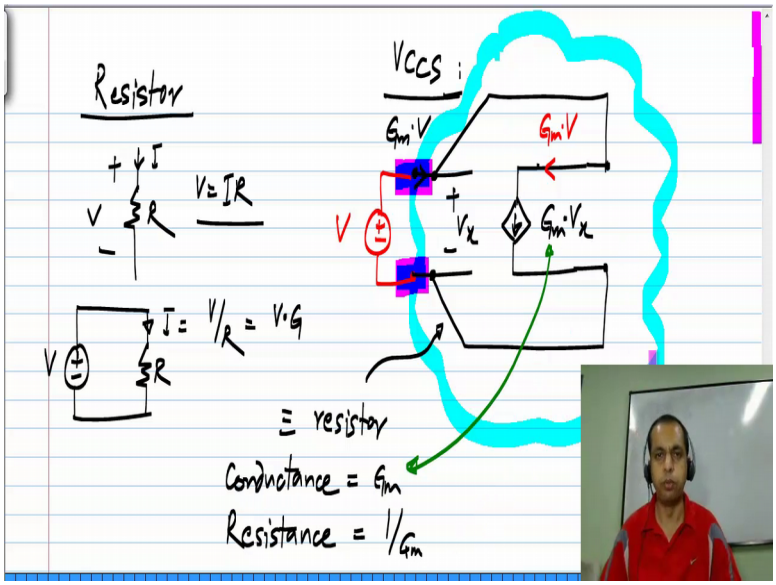

I will just illustrate what can be done with controlled sources. As I said they are model for more complicated circuits, but here I will just show you that some other elements that we know can be synthesized using control sources or their values can be altered and so on. Now let us consider a resistor we know that the voltage across the resistor and the current through the resistor are related by ohms law; and the constant of proportionality is the resistance. Now let us consider this picture, where a voltage V is applied to the resistors and that causes a current I equals V by R or V times G. Now if we think of this picture, we think of the voltage resulting in a current or voltage controlling the current. We have already discussed control source which accomplishes this function that is controlling a current using a voltage that is a voltage controlled current source.

So, what happens in that case, if we take a voltage controlled current source, there is a certain voltage V x. And let me define this to be G m times V x. So, what it says is if I apply a voltage V here, a current G m times V will flow over there. What is the resistor do, if V is applied across it, it draws current I which is V times G from the voltage source

itself and that is scenario can be easily arrange in this picture. This G m times V I could have connected to this any circuit. Now I will choose to connect it back to my circuit. So, what happens this G m times V will flow here and it will actually flow from this voltage source. So the current flowing out of the voltage source is G m times V. Now if you consider the circuit within this boundary that is between these two terminals, what do you see as far as this voltage source is concerned when it is connected to this particular circuit, it draws a current G m times V that is it draws current proportional to the voltage.

So, from those two terminals, you cannot distinguish with this from resistor. So, these entire circuit inside here is equivalent to a resistor and its conductance is given by G m, which is the proportionality constant of the voltage controlled current source or equivalently its resistance is given by 1 by G m. So what we have here really, we have voltage controlled current source and the controlled current is connected back to the controlling terminals. So, we end up with the two terminal elements, there only these two terminals, and between these terminals, there is linear relationship between current and voltage that is because of the linearity of the controlled source. So, this entire arrangement just looks like a resistor. So, you can take a controlled source and synthesize resistor format.

So, if I think of resistor it has two terminals and there is relationship between the voltage across those two terminals and the current flowing to the terminals. If you look at voltage controlled current source, the controlling voltage and the control current are at two different pairs of terminals, but we can always connect them together form a resistor. So, this is something useful to remember that a voltage controlled current source connected back on itself, behaves like a resistor and we can find the resistance value.

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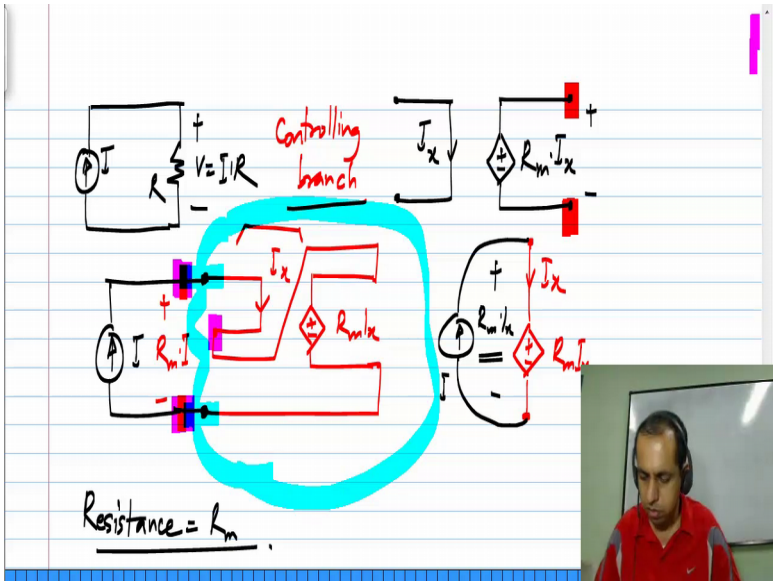

Now, some of you would guessed already; we could also use the other picture that is we can think of a resistor has responding to a current I to produce a voltage V equals I R across it. So, now if we think of this picture with controlled sources, we need a current controlled voltage source. There is a certain current I x, this will produce the voltage which is R m times I x between these terminals. Now, what do I want to realize a resistors, let say I have a current I, I must sense this current that is I must place this controlling branch in series with this. So, I will show it like this, this is I x and this is the controlling branch and this current must flows through there. And I want the voltage between these two to be proportional to the current; and here I have the voltage between these two points to be proportional to the current I x.

So, what do I do I just place the controlled branch in series with this whole thing. Now this schematic looks unnecessarily complicated, but that shows the thought process. I sense the current and then I have this voltage which is proportional to the current. So, I place it in series with this branch, which is the short circuit so that across these two terminals. Now I have voltage which is R m times I x, which is equal to I. So, clearly like before if I look at this equivalent two terminal element, so it will look like a resistor and value of the resistance is R m. So, you can use a current controlled voltage source also to synthesize a resistor. So, this you will find useful later, when you are able to implement control sources using active element like transistor, you will able to realize the variety of functions, which may not be physically possible very easily, but you will able to do this.

I will show one example of it soon, but they will be lots of example where you can realize exotic V I characteristic using control sources. Now this schematic looks very complicated, the way I would normally draw it is simply show a controlled voltage source, whose value is R m times I x; and I label I x here, so obviously if I drive this with current I across this I will have R m times I x.

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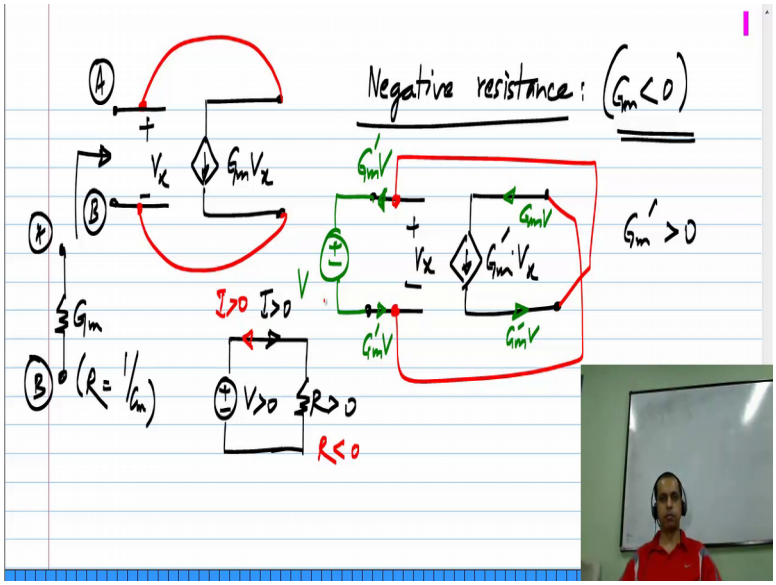

Now, just as one example of exotic stuff that is not possible with physical elements, but you can realize using control sources is this. We already saw that connecting a voltage controlled current source like this that is V x G m times V x realizes a conductance equal to G m or resistance which is 1 by G m between these two terminals. Let me call this A and B, it will look like a resistor. Now one thing is that a physical resistor is constrained to have a positive resistance that it is always dissipate powers, we look at those aspects later whereas a resistance synthesized using control sources can equally will be negative resistance. And in this particular arrangement, we need G m to be less than zero in that case it realizes is a negative resistance.

So, another way to think about it is that let say you had a controlled source, G m primes times V x and G m prime happen to be more than zero; still we can realize negative resistance, all we have to do is to connect this here and this over there. Then if I connect a voltage source V, a current G m times V will flow there, a current G m times V will flow there, we can see that the current direction is like this. If you trace it around with

the circuit, where this G m prime is a positive number, so that correspond to a negative resistance; if you have a positive resistance and a positive voltage V, what it means is that a current fill flow in this direction. Now, if this resistance is smaller than zero that is if the resistance is negative then the current will flow in that direction, current in that direction will be positive. It will push the current back into the voltage source, and that is what a negative resistance does, so that is one example of exotic things that can be synthesized using control sources.