Basic Electrical Circuits

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Lecture – 93

So, far we have described the two ports using the relationships between the port currents and port voltages, they turn out to be linear combinations. In some contexts, it is useful to have a circuit representation for the same relationships; that is what we going to look at in this lesson**.**

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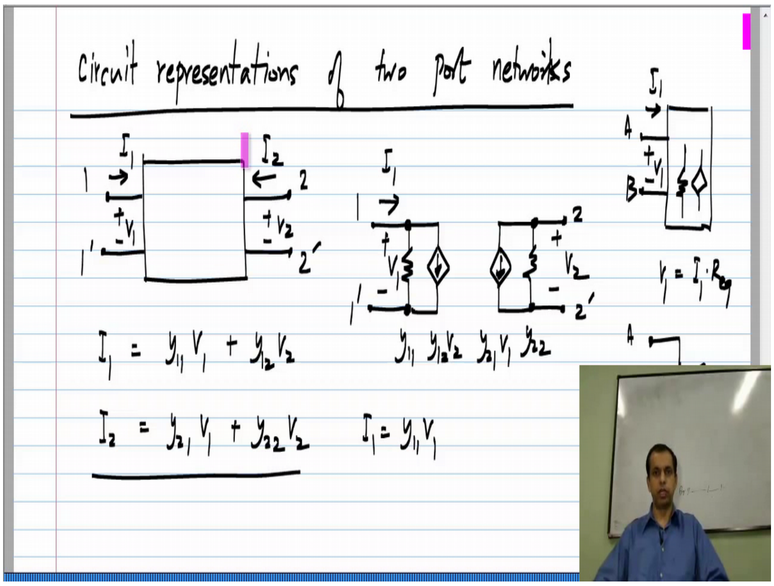

So, let say we have a two port and we choose to use y parameters that says that I 1 is y 1 1 V 1 plus y 1 2 V 2 and I 2 is y 2 1 V 1 plus y 2 2 V 2. It would be useful to have an equivalent circuit which realizes these equations, this is analogous too, let say you are given a box with linear elements inside. Then, you could provide the relationships algebraically, V 1 equals I 1 times R equivalent or equivalently you can say, let say this is terminal A and terminal B. You could say that between A and B you have this equivalent resistance; you could show this picture instead. What we are going to do is similar to this; instead of showing the equations we will show the picture.

So, for each of these terms there will be a corresponding element, let say this is port 1, we have V 1 across it. The current flowing into port 1 is a sum of two parts y 1 1 times V 1 plus y 1 2 times V 2. First look, let us look at this y 1 1 times V 1. So, it is flowing into port 1 and it is also related to the voltage between the same two terminals 1 and 1 prime. Clearly, if you had just this part, let us say I 1 equals y 1 1 times V 1 that would correspond to a conductance or a resistance.

So, if I have a conductance whose value is y 1 1, it will draw a current, which is y 1 1 times V 1, because it is placed across V 1, across this conductance we have a voltage V 1. Now, we have the second part y 1 2 times V 2, so this is 2 1 2 prime and V 2 is over there, so there is a current drawn in port 1 in response to a voltage in port 2. So, this is clearly a dependent source or a voltage controlled current source, whose value is given by y 1 2 V 2.

Similarly, if you look at the second equation we have I 2 equals y 2 2 times V 2; that is one part of it and that is the relationship between the voltage on port 2 and the current in port 2, so it is represented by a conductance whose value is y 2 2. And this last part y 2 1 times V 1 is represented by a controlled source like this, it is I 2. So, it is the current drawn from port 2 and it is proportional to V 1; that is voltage elsewhere in the circuit. So, it is model y, a voltage controlled current source and it is value is y 2 1 V 1.

So, this picture with these four elements 2 conductance's and 2 controlled sources says exactly the same thing as, what this equation is saying. Sometimes, when you are analyzing circuits, it is useful to put down this picture instead of the two port and sometimes some of these relationships becomes very obvious when you put down the picture instead of manipulating equations. Now, similar things exist for all four types of parameters; that is, what we are going to look at.

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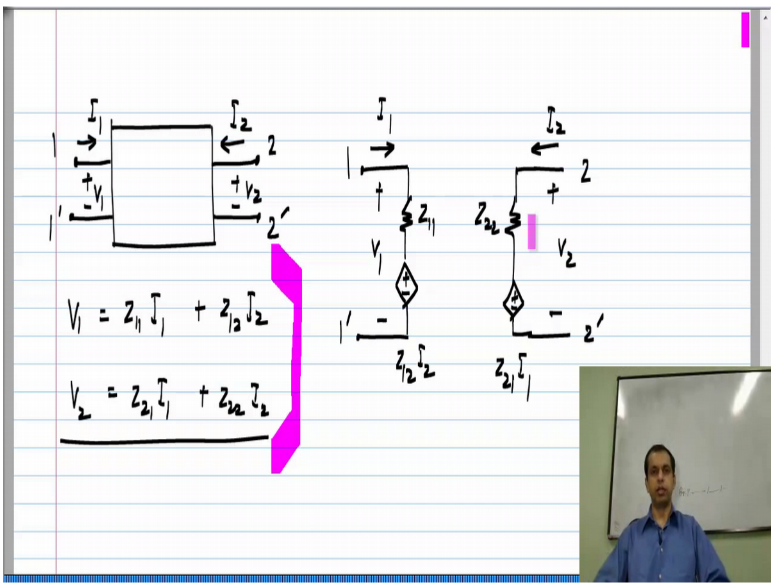

Now, we consider the z parameter representation to the two port, which gives you V 1 and V

2 as linear combinations of I 1 and I 2. So, again let say this is port 1 and a current I 1 flows into that port and we have V 1 across it. We see that V 1 is the sum of two quantities so; that means that, there should be some two voltage drops in series to realize this sum. Now, the first one is z 1 1 times I 1; that is a voltage drop which is proportional to the current flowing through the port. So, if I have a resistance whose value is z 1 1, the voltage across that will be z 1 1 times I 1, because I 1 is flowing through z 1 1.

Now, second part of it z 1 2 times I 2, it depends on the current elsewhere in the circuit that is in port 2. So, we have the second port V 2 across it and I 2 through it, so in series with this resistance of value z 1 1 we will have z 1 2 I 2. And similarly, for the second equation we have a series combination of two voltage drops, one which is z 2 1 times I 1, because it depends on the current elsewhere in the circuit. We have a current controlled voltage source, whose value is z 2 1 times I 1 and in series with that we have a resistance z 2 2, because I 2 is flowing through that z 2 2, it creates a voltage drop z 2 2 I 2.

So, again this equivalent circuit enforces the same relationships between the port voltages and port currents as do these set of equations. Sometimes, instead of using these equations it is useful to write this picture and then, may be add in whatever else comes from the rest of the circuit and proceed with your calculations.

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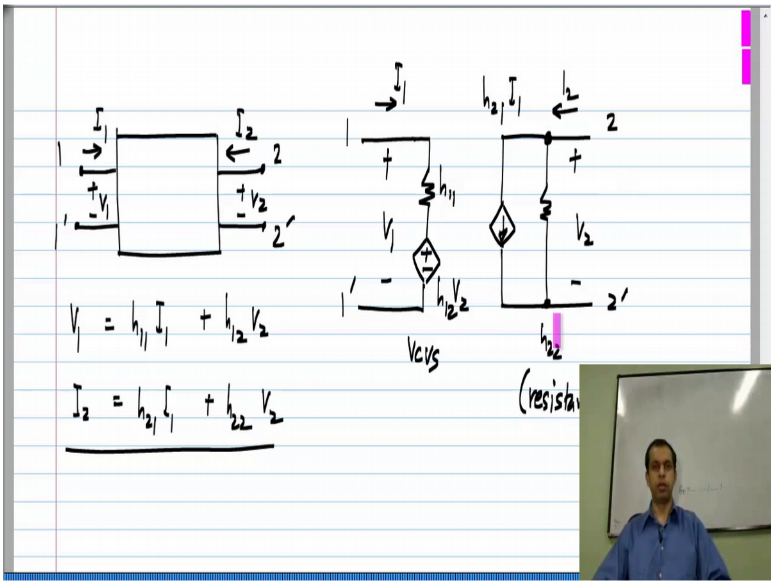

Now, we will look at the h parameter representation of the two ports. Here, again we have two equations, V 1 is the sum of two quantities since the voltage is the sum of two quantities. We can think of each of these as individual voltage drops, which appear in series to form V 1.

And in the second equation I 2, a current is sum of two quantities since these two currents sum up to give this you can think of these two as parallel branch currents, which add up to give I 2. So, as you expect from the name hybrid parameters, the equivalent circuit will also be hybrid, on one side it will have series branches and on the other side parallel branches.

So, let say this is port 1 with V 1 across it and I 1 through it and this is port 2 with V 2 across it and I 2 through it. So, V 1 is a sum of these two drops, so we have a resistance whose value is h 1 1 and we have a controlled source is V 1 depends on V 2. So, this is a voltage controlled voltage source, whose proportionality constant is h 1 2 or whose value is h 1 2 times V 2. For the second equation we need parallel branches, because we need to add currents, so we have I 2 h 2 2 V 2, so I is proportional to V, so this is a conductance and the conductance is h 2 2 or the resistance value is 1 by h 2 2.

Finally, we have a current controlled current source, because I 1 is a current the resultant I 2 is also a current. So, this term is created using a current control current source on the gain of the current control current sources h 2 1. So, this is the, what we have on port one we have series branches on port on port two parallel branches.

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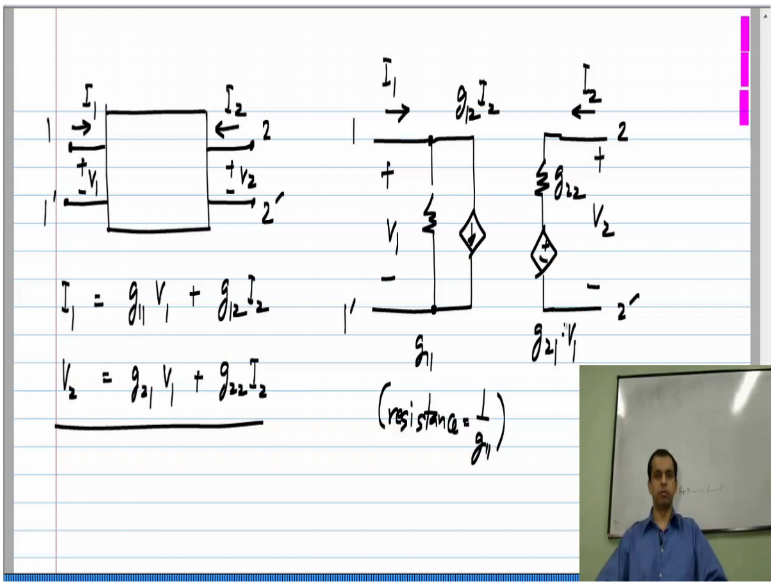

Finally, we will look at g parameters again we have two equations each with sum of two terms the first equation result in a current, which is the sum of two currents. So, we need parallel branches to implement this, the second equation is the voltage, which is the sum of two other voltages, so we need a series combination to implement that one. So, port 1 we have the voltage V 1 and the current I 1 and port 2 with voltage V 2 and current I 2 . So, the first one is a current, so we have sum of two branches g 1 1 and V 1 that represent the conductance of g 1 1 or a resistance of 1 by g 1 1, the second one gives the dependence of I 1 on I 2, so this is the current controlled current source whose gain is g 1 2 or whose value is g 1 2 times I 2.

Now, on the other side or the other port we have the voltage or the sum of two other voltages V 2 equals g 2 2, I 2 voltage proportional to current, which is obtained using a register whose value is g 2 2 and in series with this is the voltage controlled voltage source V 2 equals g 2 1 V 1, so it is a voltage controlled of gain g 2 1. So, this is equivalent circuit for the g parameter two port. So, like I said any network can be represented by any set of parameters of course, sometimes some of these parameters are infinite valued in which case you do not use them, but in general you could use any one of them.

Similarly, you could use any one of these equivalent circuits, now again, which one you choose is based on connivance. Exactly like either choosing to calculate with resistances or conductance's here we do have more choices, because we have ports more variables and so on.