Basic Electrical Circuits
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Lecture - 89
Calculations with a two port element

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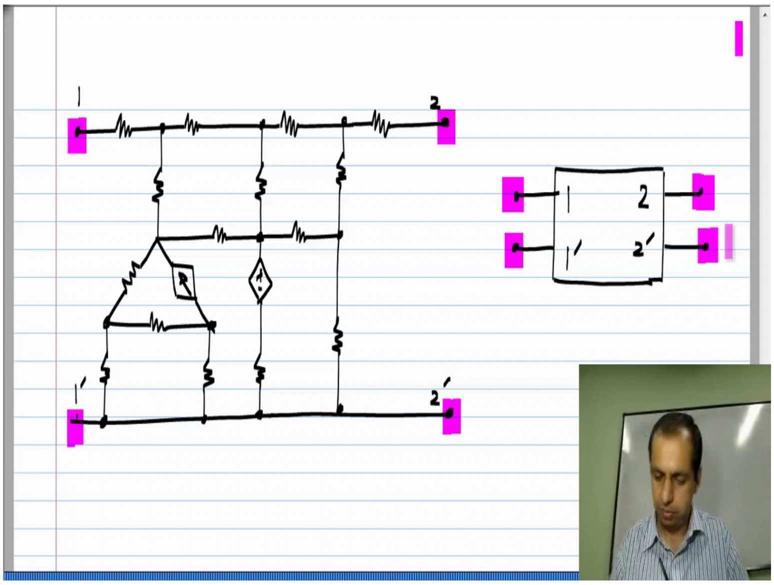

In this lesson, we will look at the utility of these two port parameters. Let say we have a complicated circuit something like this; and it could be even more complicated than this; it could have hundreds of components. Now I have marked these ports 1, 1 prime and 2 2 prime, let say you are allowed to make connections only to these. So, then in that case, so I will represent this is as the box and you are allowed to make connections only to these terminals. So, in that case, you do not need to analyze this circuit over and over, you can imagine that analyzing such a circuit is quite a job, it is complicated. And like I said it could be lot bigger than this, this is only limited by what I could draw in a short time, it could have hundreds of components.

As long as you are allowed to make connections only to a two ports then the whole thing can be reduced to a set of two port parameters, and it can be anything, it could choose y parameters, z parameters, h parameters or g parameters. Once that is done, any calculation that you need to make with this circuit, you can make with the two parameters set. Now what are the possible calculations that you could be asked to make, I will show you an example.

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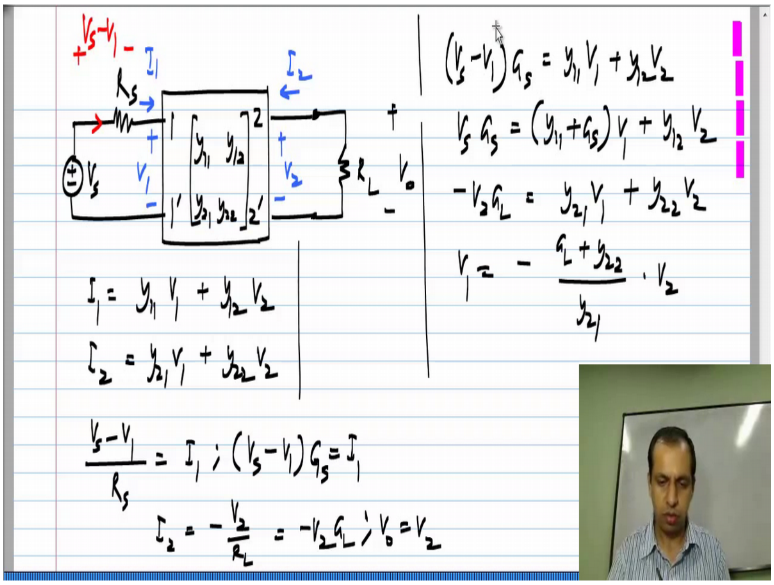

For instance let say you had a circuit whose y parameters are given or you have calculated them already. Now, I could connect the source like this; V s in series with the resistance R s, and I could have a load resistance to this side. And I define the voltage across the load resistance be V naught. I need to calculate V naught by V s. Now I took the scenario, because this is a common one involving amplifiers on one side; you connect the source, the source could be imperfect; so it has the series resistance and on the other side you connect a load. So, now, again like I said we do not need to know what is inside, they could it could have hundreds of components. You need to do the calculation only once to determine these y parameters and after that you can simply use the y parameters.

So, I am going to show an example. Now the y parameters relates V 1, I 1, V 2 and I 2; and those relations we know which is 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. And now there are constraints imposed by whatever we have connected on the two sides. Firstly, let us take the circuit connected to port 1, we have V s and R s connected. So, the voltage drop across R s is V s minus V 1 that is pretty obvious considering Kirchhoff's voltage law around this loop. And the current through R s is this current I 1, so clearly V s minus V1 divided by R s is I 1. And let me write this in terms of conductance, it is a little more convenient. So, V s minus V 1 times G s is I 1, where G s is 1 by R s. And if you look at the output side this V 2 is the voltage across R L, and I 2 is the current through R l, but in the upwards direction. So, you see that I 2 is nothing but minus V 2 by R l or minus V 2 G l. And V naught is nothing but V 2, because V naught is defined across this and that is the same as V 2.

So, now from these, we have two equations relating the voltages and currents of the two port. This is the a generic relationship for the two port. And whatever we connect on the outside imposes some constraints, we add to that and solve for V naught by V s or V naught in terms of V s. We eliminate all of the intermediate variables V 1, V 2, I 1 and I 2 we have enough equations to do that. So, let us go about doing that thing. So, I will first substitute this into the first equation, I have V s minus V 1 times g s to be y 1 1 V 1 plus y 1 2 V 2. So, this gives you V s G s to be y 1 1 plus G s times V 1 plus y 1 1 V 2. And I will substitute this I 2 equals minus V 2 G L in the second equation, which gives me minus V 2 G L is y 2 1 V 1 plus y 2 2; V 2 and this gives you V 1 to be minus G L plus y 2 2 divided by y 2 1 times V 2.

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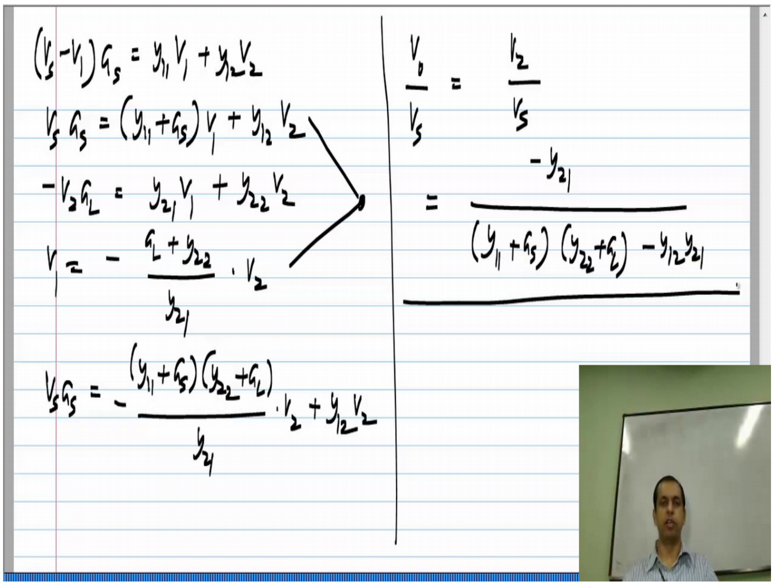

So, let me copy those over, and from these two, I need to eliminate V 1, so that I have a relationship between V s and V 2; and V 2 is nothing but V naught the output voltage that I am interested. So, putting this into that one I will get V s G s to be y 1 1 plus G s y 2 2 plus G l divided by y 2 1 times V 2 plus y 1 1 V 2. Now by manipulating this, I can get V naught by V s which is the same as V 2 by V s to be minus y 2 1 divided by y 1 1 by G s y 2 2 plus g l minus y 1 2 y 2 1. So you can take the module of the circuit module of the two ports in terms of the two port parameters and analyze the whole circuit. We do not need to look at the insides of the circuit that is the advantage. And of course, the two port parameters could be Z, G or H instead of y. In this case, I took y as an example, but it could be described by any other set of parameters. You can do the calculations in that particular set of parameters or you can convert them into one of the other sets if that happens to be more convenient. So, this is the one of the kind of calculations that you could do.