Basic Electrical Circuits
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Lecture - 79

Now, we will discuss two port parameters.

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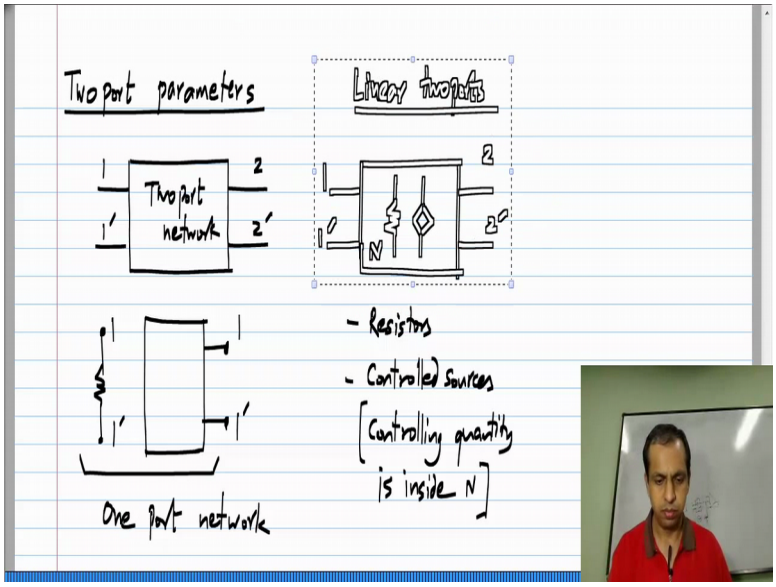

What are two ports? They are circuits with two pairs of terminals 1 1 prime and 2 2 primes provided for you to apply voltages or currents. A port is basically where you can apply a voltage or a current. Now, I did not defined this earlier, but all the two terminal components we have a resistor for instance, this can be considered as a one port element, because you have a pair of terminals across which you apply a voltage or you can apply a current. Similarly, a circuit with a single pair of terminals available to you to apply a voltage or current, it is a one port.

So, this is a one port circuit or a one port network, whereas here we have a two port network. Now, why are these things are interest? Many practical systems are of this form, now you can have more than two ports, but the lots of practical systems where you think of applying the input somewhere and take it the output elsewhere. So, in other words you apply the input to one port and take the output from another ports, all amplifiers are like this and amplifiers are at the heart of all electronics. So, that is why modeling of two ports is important.

Now of course, you can have more than two ports, but whatever modeling we do for two ports can be generalized into higher number of ports. Now, the particular type of two ports will concern ourselves with are linear two ports, these are two ports with only linear components in them, meaning you have resistors inside and controlled sources inside and the controlling quantity is inside the network N. So, that means that, the network N is completely linear and most importantly we do not have independent sources inside, these are completely linear two ports.

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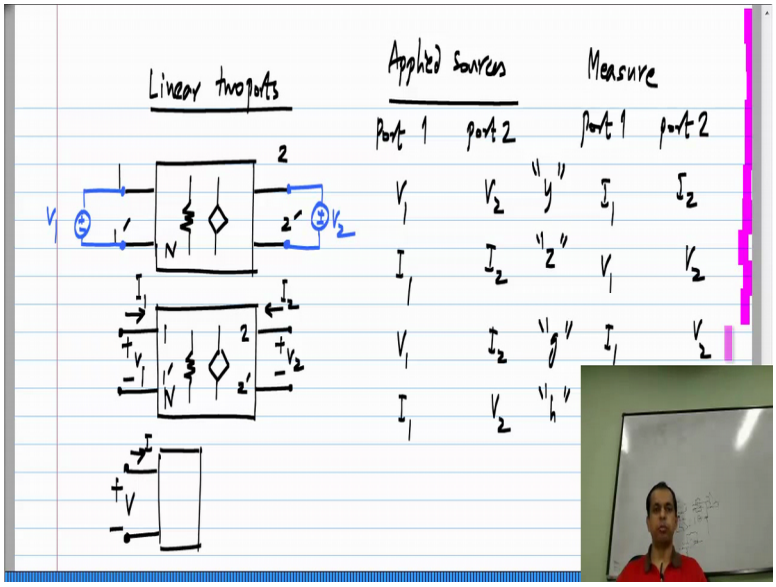

Now, let us take one of these linear two ports and let us say that we apply a voltage V 1 to one side, for now I do not do anything to the other side. If we did this, then by linearity of this circuit we know that the currents here in these terminals as well as everywhere in the circuit will be just proportional to V 1. Similarly, if I apply a voltage source only to the right side; that is V 2, then the currents in these terminals will be proportional to V 2 as well as everywhere else in the circuit will also be proportional to V 2.

Now, if you connect voltage sources to both sides V 1 and V 2, then the currents in these terminals 1 1 prime as well as 2 2 prime and also everywhere in the circuit will be a linear combination of V 1 and V 2. Now, as long as only these two terminal pairs are exposed to us; that is 1 1 prime and 2 2 prime, all we need to know is the linear combination for the currents that going to the two port, we do not need to know the

internal details of the circuit. This is slight specifying the equivalent resistance of a one port.

If you have a pair of terminals all you need to know is the ratio between voltage applied across the pair of terminals and the current flowing through the terminals. Similarly, here we have two sources, so each of these currents will be a linear combination of these two sources. We need to know, what that linear combination is; that is all. So, that characterization is known as two port characterization or characterization using two port parameters.

So, what I will do is, first let me define the currents and voltages as seen from outside, 1 1 prime. So, V 1 is defined this way and I 1 is defined as going into the terminal which is defined to be positive for V 1. Notice that, this is analogous to if you had a one port we would use passive sign convention and define V like this and I like that and either evaluate the characteristics or plot it at whatever. So, this is like passive sign convention for two ports.

Similarly, for port 2 I will define V 2 and I 2 like this and this is terminal 2, this is 2 prime, let me write these things inside the box just for convenience, this is 1 1 prime 2 2 prime. So, now, like I said you can apply sources to both sides and the resulting branch voltages and currents everywhere will be a linear combination of these two sources. Now, there are different possibilities, in this example I applied voltage sources to both sides, but this is not necessary. There are many possibilities, particularly we have two types of sources, a voltage source and a current source and we have two ports, port 1 and port 2. So, there are two times two four possibilities.

We can apply voltages to both ports and measure or describe the currents; that is we measure the current I 1 at port 1 and current I 2 at port 2. So, this is one possibility, similarly we could apply currents I 2 and I 2 two ports 1 and 2 and measure the resulting voltages V 1 and V 2. If you think of it, this is like measuring either the conductance or the resistance of a circuit, if you apply a voltage and find the current, that current will be conductance times the voltage. Alternatively, if you apply a current and find the voltage, that voltage will be resistance times the current.

So, now, this is more elaborate you have more parameters, but it is analogous to that and you can also mix and match, you can apply a voltage to port 1 and current to port 2 and

measure the current at port 1 and the voltage at port 2. And finally, you can apply current at port 1, apply a voltage at port 2 and measure the voltage at port 1 and the current at port 2. So, these are all distinct possibilities and each gives you a different set of parameters.

What do I mean by parameters, you have these Constance of proportionality in the linear combination, like I said the two unknowns for instance I 1 and I 2 in the first case we will be linear combinations of V 1 and V 2 each of them will have some scaling factor for V 1 and V 2 those are the parameters. As you can see there are four possible parameters, because I 1 is something times V 1 plus something else times V 2. So, there are two of them, similarly I 2 is something that V 1 plus something else time V 2. So, there are two more, there are four possible parameters that you need to specify in a two port.

So, similarly in the second case V 1 and V 2 will be linear combinations of I 1 and I 2 and you specified the factors that appear in the linear combination. So, all of these things will give you different sets of parameters and they have names I will give the reason for the names later. So, the first set where you apply voltages and measure the currents you have what are known as y parameters and in the second set, where you apply currents and measure the voltages, you have z parameters and when you apply a voltage to the first port and current to the second port and measure the other quantities, you have G parameters.

Finally, when you apply a current to the first port, voltage to the second port you have h parameters. So, these are possible two port parameter sets and all of them are equivalent, now like before for some circuits only some of them could be defined and the others could be undefined. But, if you have a circuit for which all of them are defined then all are equivalent descriptions, which one you choose is this purely on convenience and this is just like some times in calculations you would use conductance's instead of resistances or you would use Thevenin's equivalence instead of Norton equivalence and so on.

In the following lessons I will describe each of these parameters sets and show you an example that is a very simple circuit for which we will calculate the parameters and I will also show an example, where only one of these parameters could be defined or some of the parameters sets could be undefined.