Basic Electrical Circuits

Dr Nagendra Krishnapura
Department of Electrical Engineering
Indian Institute of Technology Madras

Lecture – 84

Now I will take an example circuit and calculate it is z parameters. I will take the same circuit that I took for the y parameter example, so that you can relate different parameter sets for the same circuit.

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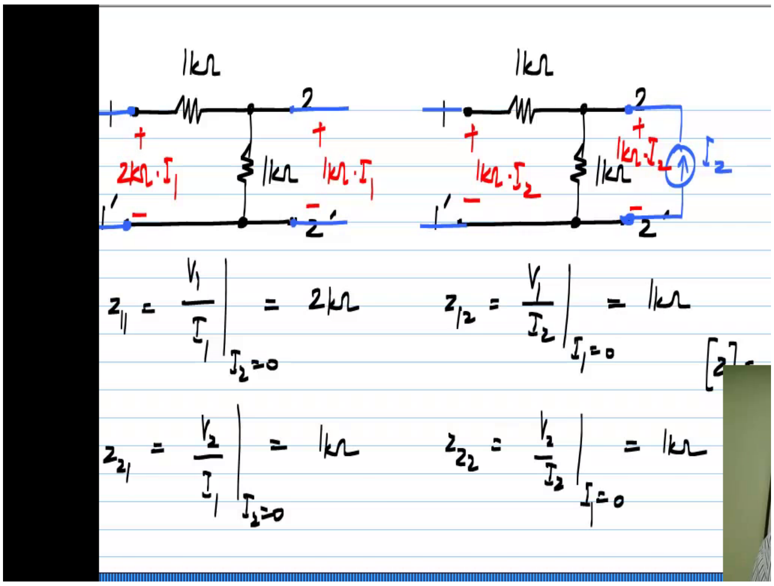

So, this is the circuit I took and I have two cases for measurement, one in which port 2 is left open circuited and a current source is connected to port 1 and in the other case, where port 1 is left open circuited and a current source is connected to port 2, so extremely simple circuit, very easy to analyze. So, I 1 flows through these two resistors, so the voltage here across port 1 is the series combination of these two resistors 2 kilo ohms times I 1, whereas the voltage across port 2 is I 1 times this resistor 1 kilo ohm.

In this circuit, no current flows through this 1 kilo ohm, because it is in series with an open circuit. So, the voltage drop across this is also zero, all of these I 2 flows into 1 kilo ohm, giving you a port 2 voltage of 1 kilo ohm times I 2 and the same voltage appears here and that is 1 kilo ohm times I 2. So, from the first circuit in which we have port 2 open circuited will get z 1 1, which is V 1 by I 1 with port 2 open circuited I 2 equal to 0 to be 2 kilo ohms and we also get z 2 1, which is V 2 by I 1 with port 2 open circuited to be equal to 1 kilo ohm.

So, z 1 1 is nothing but, the resistance looking into port 1 with port 2 open circuited and if you look into port 1, you will see the combination of these two resistors in series which gives you a 2 kilo ohm resistance. Or let us go to the other circuit and from this we will get z 1 2, which is V 1 by I 2 with port 1 open circuited which gives you 1 kilo ohm and z 2 2, which is V 2 by I 2 with port 1 open circuited, which is also 1 kilo ohm.

So, these are the four z parameters and z 2 2 here is nothing but, the resistance looking into port 2 with port 1 open circuited. If you look into port 2, you we will see this 1 kilo ohm and this 1 kilo ohm which is hanging, so it does not contribute anything. So, the looking in resistance into port 2 is just 1 kilo ohm and that is what we see. So, the z parameter set of this particular circuit is 2 kilo ohm, 1 kilo ohm, 1 kilo ohm and 1 kilo ohm and you can verify for yourselves, that this z matrix is the inverse of the y matrix which you derived for the same circuit in the earlier example.

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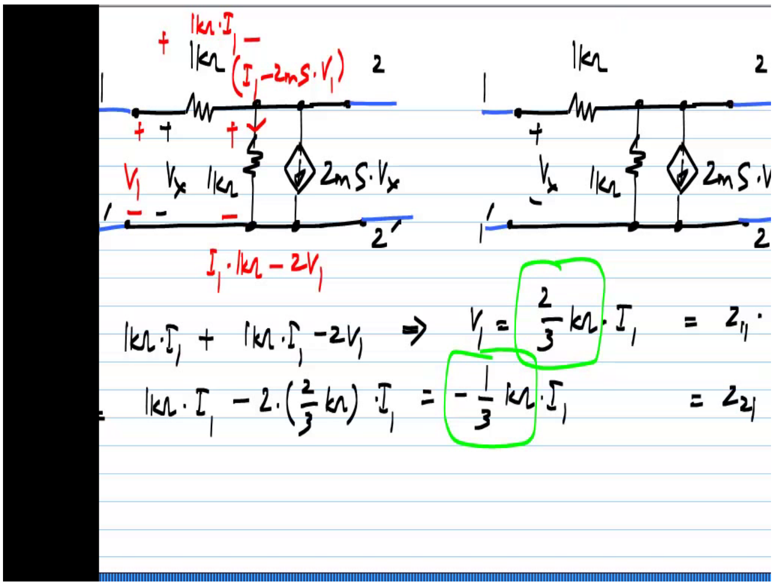

Now, let us make the circuit slightly more complicated by adding a control source, again I will take the exact same example I took earlier, so that you can relate different parameter sets for the same circuit port 1, port 2, 1 kilo ohm, 1 kilo ohm and 2 Millisiemens. So, I will go through this analysis quickly, because circuit analysis by now is familiar to you, so you can work this out yourselves and compare your answers to what I derived.

So, again I need two cases, one in which port 2 is open circuited, a current is applied to port 1 and another case, where port 1 is open circuited and a current is applied to port 2.

So, now, we have a slightly more complicated situation with the controlled source. Now, if you observe this circuit, I 1 flows through this 1 kilo ohm, then the parallel combination of these two. So, the voltage drop across this is 1 kilo ohm times I 1, a current through this resistor is I 1 minus whatever current is flowing through the current source, which is I 1 minus 2 Millisiemens times V x and in this circuit, you see that V x equals V 1, because the voltage here is V 1.

So, V x is the same as V 1, so I will write this as I 1 minus 2 Millisiemens times V 1, so that is the current flows over there. So, the voltage drop across this is this current times 1 kilo ohm, which is I 1 times 1 kilo ohm minus 2 Millisiemens times 1 kilo ohms times V 1, which is minus 2 V 1 and also the voltage V 2 is nothing but, the voltage drop across this 1 kilo ohm resistor. So, I will write these two equations. First of all V 1 equals the sum of voltage drops across this one and that one, which is 1 kilo ohms times I 1 plus 1 kilo ohms times I 1 minus 2 V 1.

From this we see that V 1 is 2 3rd kilo ohms times I 1 and we know that, V 2 is the voltage drop across this. So, v 2 is 1 kilo ohm times I 1 minus 2 V 1 and V 1 we have already calculated. So, it is 2 times 2 3rd kilo ohms times I 1, which is basically minus 1 3rd kilo ohm times I 1 and with port 2 open circuited, we know that V 1 is nothing but, z 1 1 I 1 and V 2 is nothing but, z 2 1 I 1. So, z 1 1 is this quantity and z 2 1 is that quantity.

So, we need a little more calculation and I went though it quickly, but the analysis of the circuit with the current source I 1 applied is routine by now. So, you should be able to do this yourselves and I will do it for the other case as well. Let me copy over this part of the circuit.

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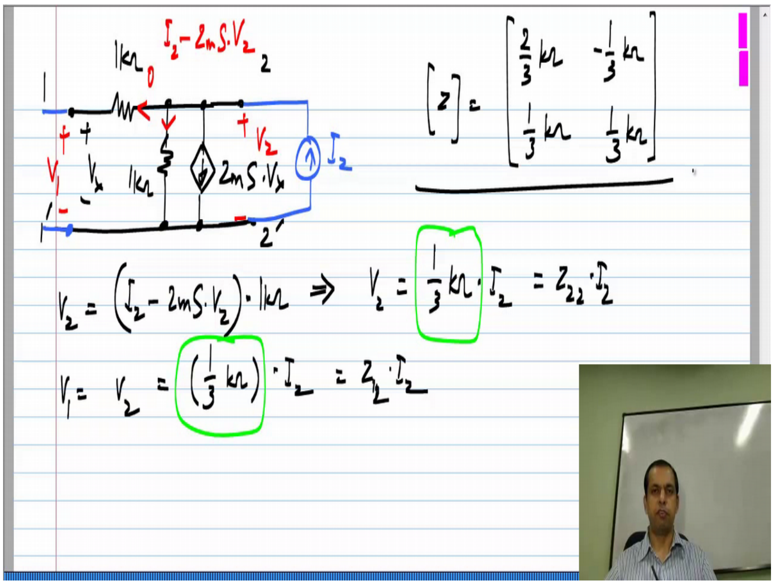

Port 1 is open circuited, now again the current through the 1 kilo ohm resistor is zero and V 2 equals V 1 in this particular circuit, this is not true in general of course, and also V x happens to be equal to V 1. So, now, the current through this 1 kilo ohm resistor, by the way through this it is zero and through this vertical 1 kilo ohm resistor is I 2 minus whatever current is flowing through the controlled source, which is I 2 minus 2 Millisiemens times V x, which is the same as V 1 which is also the same as V 2. So, I am going to write that right away.

So, now, this voltage drop V 2 is the current through this 1 kilo ohm resistor times the 1 kilo ohm resistance. So, V 2 we get it to be I 2 minus 2 Millisiemens times V 2 times 1 kilo ohms and from this, we get V 2 to be 1 3rd of a kilo ohm times I 2 and we also said, V 1 is the same as V 2 which is also 1 3rd kilo ohm times I 2. And we know that, with port 1 open circuited V 2 is nothing but, z 2 2 I 2 and V 1 is nothing but, z 1 2 I 2.

So, this is z 1 2 and that is z 2 2, the z parameter matrix for this circuit turns out to be 2 3rd kilo ohms minus 1 3rd kilo ohms, 1 3rd kilo ohm and 1 3rd kilo ohm. Again, you can go back to the old or y parameter example and verify that, this is the inverse of the y matrix for this circuit.