Circuit Theory
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Lecture - 22
Problem Session 5: Single and Double Tuned Circuits

We will talk about this, on a latter occasion. This is the twenty second lecture and we will going to work out problem set 6. This is our problem session 5. The first problem that we are going to work out is 9 point 1.

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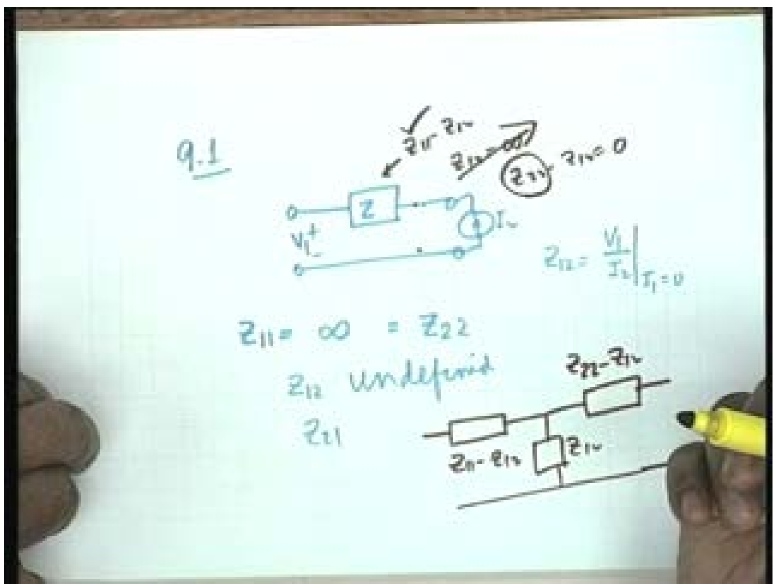

The problem says, find the z y h and t parameters, well, we have not done h and t yet in the class, so we will confine to z and y parameters of the network shown in the figures. Some of the parameters may not be defined for particular circuit configurations. Now what does that mean? Some of the parameters may not be defined, in other words, if that parameter blows up, if it goes to infinity, then it is not defined because we do not know what infinity is. For example, you look at the first network. We have an impedance z, this is the 2 port and you see, that if I want to find out the z parameters, for example, z parameters, z 1 1 keep this open and measure here, obviously, it is infinity. Keep this open and measure at the input, z 1 1 is infinity, so is z 2 2, agreed.

What about z 1 2? z 1 2 by definition, what is the definition? V 1 by I 2 with I 1 equal to 0. So if I connect a current source I 2, pardon me, connect a current source and measure the voltage here. No current flows, the current source is ineffective and therefore,

Student: (..)

Sir: What is infinite?

Students: V 1 is 0, I 2 is finite.

Sir: I 2 is 0? So it is undefined and therefore, z 1 2 is undefined, so is z 2 1, that equal the reciprocal, and therefore, we cannot find out the z parameters of this. Our conclusion is, z parameters are not defined. Now one of things, as I go ahead, I will give you the tricks of the trade. One of the things that you can exercise is, in such a network, instead of calculating z 1 1 z 2 2 z 1 2, every time you get a network, it may be useful to compare it with the T equivalent circuit that we had formulated.

What is the T equivalent circuit, in terms of z parameters? z 1 1 minus z 1 2, z 1 2 and z 2 2 minus z 1 2. Remember this and compare with this. If you compare with this the remaining ways of identifying, for example, this you could identify as z 1 1 minus z 1 2. If I do that, then obviously z 1 2 is infinity. Well, undefined, this is open, infinity is also undefined, undefined and z 2 2 minus z 1 2 is equal to 0 because there is a short circuit here and therefore, z 2 2 is also undefined or infinite, whatever the case may be and z 1 1 minus z 1 2, well this should also be infinity then.

One of the ways is to compare the 2 equivalent circuits. We can do this comparison because the architecture of the given network is a 3 terminal one, correct? We can compare and immediately write down the z parameter.

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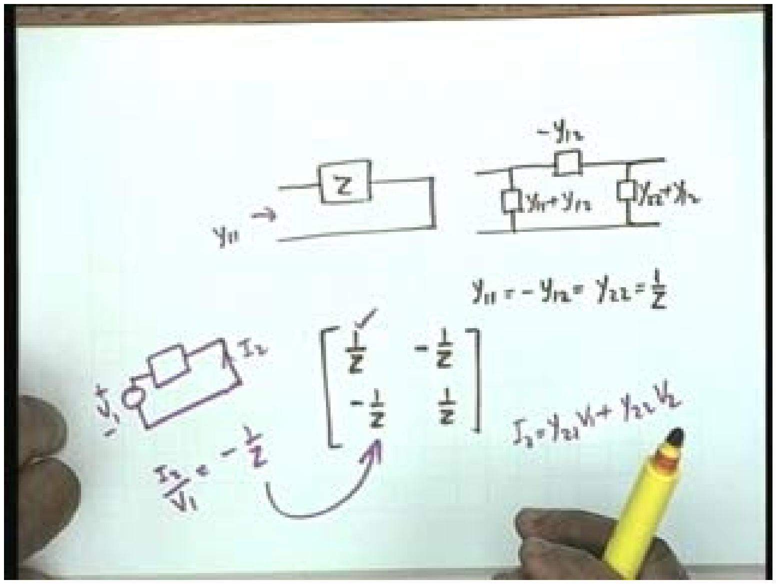

On the other hand, if I want to find out the y parameters of this, I will first find the easy way out. The easy way out is, you recall the equivalent circuit, pi equivalent circuit, which are in terms of the y parameters and this is y 2 2 plus y 1 2. By comparison, you notice that y 1 1 plus y 1 2 is equal to?

Student: (..)

Sir: No, the admittance, 0 and therefore, y 1 1 is equal to minus y 1 2. Similarly, this is also 0 therefore, this is equal to y 2 2 and what is minus y 1 2 in comparison this is equal to 1 by z and therefore, our y matrix would be 1 by z then minus 1 by z minus 1 by z 1 by z is that okay these are the y parameters and I did not calculate anything. Now let us see if the calculation gives the same thing. Suppose, I want to find out y 1 1, then what I do is, I short circuit this and therefore, y 1 1 would be simply 1 by z, as it is so.

Similarly y 2 2, by symmetry, is also 1 by z. To find y 1 2 or y 2 1, y 2 1, how do I do that? I 2 equal to y 2 1 v 1 plus y 2 2 v 2. So y 2 1 is I 2 by v 1. I connect v 1 here, I short circuit this and find I 2. You must remember I 2 enters the network and therefore, I 2 by v 1, under this condition, obviously, is equal to?

Student: Minus 1 by z.

Sir: Minus 1 by z, which is precisely what you have got here. These are extremely simple examples, but ticklish, particularly when the parameters do not exist.

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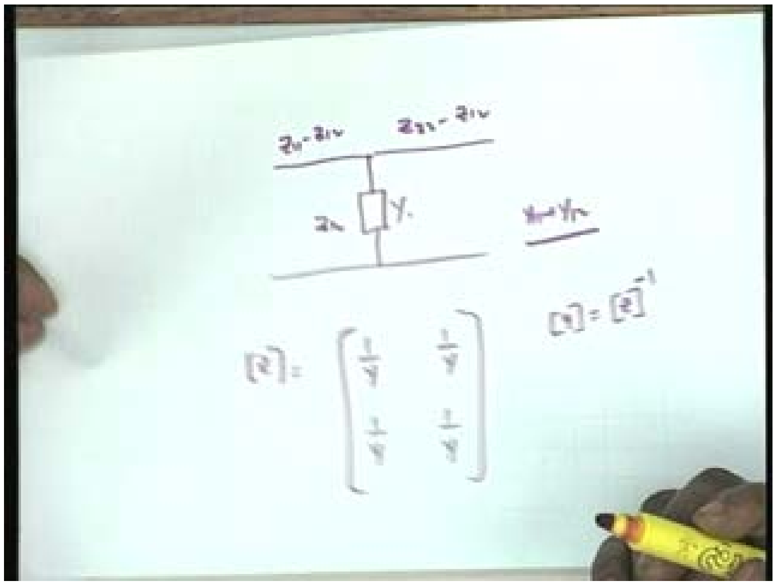

For example, for this network, for the other network, obviously, y parameters would not exist. Why not? If you short circuit this, the admittance is infinity and therefore, if one of the admittance is infinity, the parameters are not defined. That is enough to take this network out of range, as far as y parameters are concerned. You could do that by comparing with the y parameter equivalent circuit, then one of y 1 1 plus y 1 2 would have been equal to y or y 2 2 plus y 1 2. Whichever way you look at it, but you see minus y 1 2 is infinity and therefore, y 1 1 plus y 1 2 even that is finite, y 1 1 must be infinity and therefore, the y parameters are not defined.

What about z parameters? This is very simply found out, if you compare this with the z parameters equivalent circuit z 1 1 minus z 1 2, z 2 2 minus z 1 2 and this z 1 2 and therefore, what are the z parameters?

Student: Minus 1 by y.

Sir: 1 by y, now why minus?

Student z 1 1 is equal to minus 1 by 2.

Sir: No, it is equal to plus 1 by y. z 1 2 is y, 1 by y and therefore, all of them are equal. This is also one of the reasons why the y parameters do not exist. The determinant of this is infinity. This is a singular matrix. The determinant is infinity and you remember that y matrix,

Student: Determinant is 0

Sir: Oh, determinant is 0.

Student: Sir, it is a singular matrix.

Sir: That is, the matrix is singular, then you recall that y parameters are exactly the inverse z parameters, or the other way round. The z parameters exist, but the determinant z is 0 and therefore, the inverse does not exist. So the y parameters do not exist. You can only find out z parameters of this.

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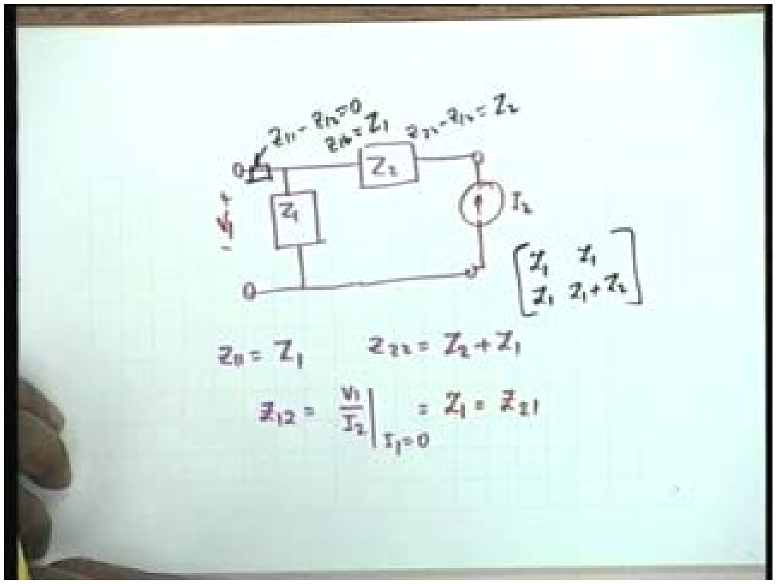

Let us do the third network here, which is a z 1 and a z 2. Once again, it is the 3 terminal networks. I can do, I can apply the definition. Let us do that for a change. The definition z 1 1, z 1 1, keep this open, so this would be simply equal to z 1.keep this open measure the impedance here z 2 2 would be, if this is open then it is simply z 2 plus z 1. Now to find out z 1 2, for example, z 1 2 by definition is V 1 by I 2 with I 1 equal to 0. So let us apply, let us connect the current source, I 2 and measure the voltage V 1 here. Obviously, this will be I 2 z 1 and therefore, this is equal to z 1 and this must be equal to z 2 1 also.

So our matrix shall be z 1, z 1, z 1, z 2 plus z 1. Now if you, there are many ways of looking at it. This is one way the other way is you compare this with the T equivalent circuit. In the other words, you write z 1 1 minus z 1 2 equal to 0, short circuit. z 1 2 the shunt element is obviously z 1 and z 2 2 minus z 1 2 equal to z 2. This element is 0, this is z 1 and this is z 2 2 minus z 1 2 and therefore, it gives the same results, that is, z 1, z 1, z 1, z 1 plus z 2, this is the z matrix.

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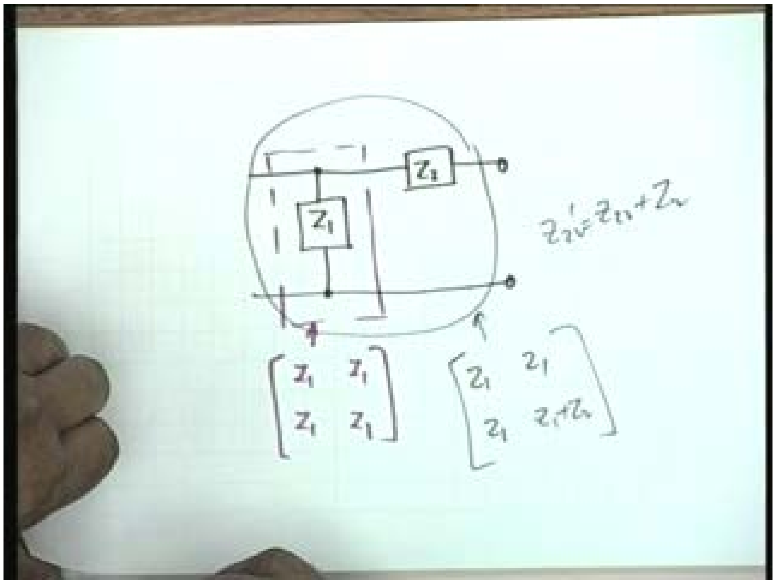

The third way of looking at this, let us exhaust these ways because this, it says that it sharpens the capabilities. If you can look at something from 3 or 4 different angles, every time it sharpens your capabilities, it gives you an enhanced tool to solve real life problems. I can look at this network as this network, let me use a different colour, I can look at this network, as this network which we have already solved, whose z parameters are z 1, z 1, z 1, z 1, agreed. These are the z parameters.

Student: Sir z 1 plus z 2.

Sir: No, only this, the pink coloured network. Then what we have done is, we have connected a z 2, in series at the output. Now what does z 2 affect? That is the question one is asking. Does it affect z 1 1? No, it does not because this will be kept open. Does it affect z 1 2? No, because once again this will be kept open, z 1 2 or z 2 1, it does not matter. If I find z 1 2, I have to connect a current generator here, an impedance in series with current generator has no effect. It does not affect z 2 1. I connect the current generator here, what is here, it does not matter because I kept this open.

It affects z 2 2, that is the only parameter it affects. How does it affect? It simply adds and therefore, the total network, now let me change the colour, the total network therefore, shall be only thing that will be affected is z 2 2, so it is z 1 plus z 2; by inspection, no calculation. But this is the way of looking at it. It is a combination of 2 networks and this element simply affects z 2 2. We shall have occasions to solve networks, in which, we will not go through such calculations. We will simply say z 2 2 prime, that is of the composite network is the original z 2 2, plus whatever is connected in series, at the output.

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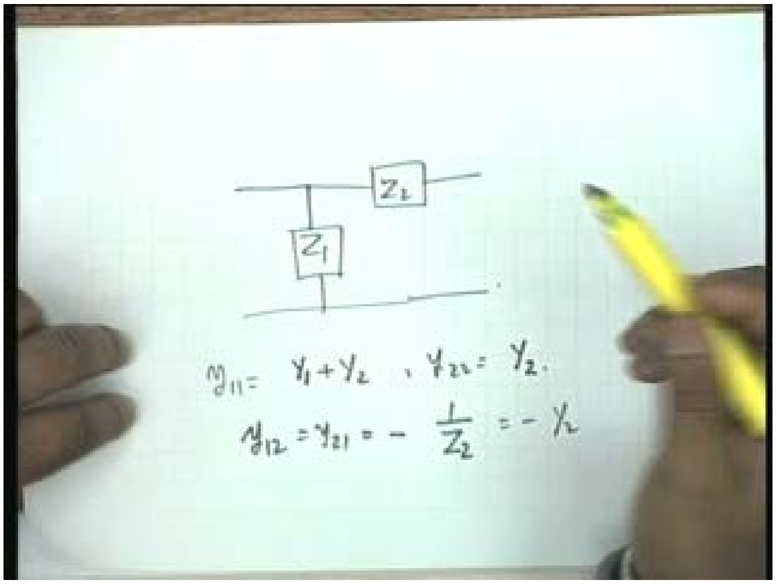

Now let us look at the y parameters. Once again the network is z 1 and z 2. Let us do it in 1 or 2 different ways, y 1 1 if I apply the definition, short circuit this and then measure the input admittance, obviously, this will be y 1 plus y 2, where y 1 is 1 by z 1, y 2 is 1 by z 2, y 2 2, if I measure here with this shorted, obviously, this will be simply y 2 2. Now can anybody tell me what would be y 1 2, without any calculation?

Student: y 2

Sir: No y 2 y 1 2 or y 2 1, they will be equal.

Student: (..)

Sir: Minus 1 by Z 2. That is correct, minus 1 by, that is minus y 2, this negative sign was missing. How did you get that not by you can calculate you can also remember the pi equivalent circuit that is that is shunt element or the not shunt bridging element between input and output that is minus y 1 2 and therefore, this would be minus y 1 2 would be y 1 z 2, so y 1 2 with minus 1 by z 2, agreed. If you remember these ways of looking into a 3 terminal network, you see things will be very easy in future.

The h and T parameters, well I will leave them to you. We have not yet done in the class and therefore, if an occasion arises, if you have problems, you can ask me. We will go to 9 point 2.

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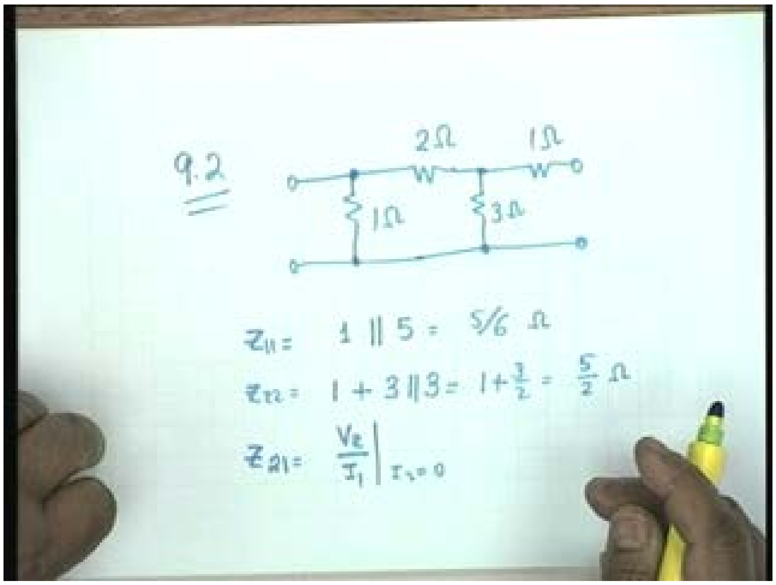

9 point 2, we will solve the simple problem first one and you will see that we will solve everything, almost everything by inspection. When we are forced to, when we are forced, we will go to methods other than inspection, but here, as you will see, it will not require 3 ohm and 1 ohm. First, by inspection, z 1 1, if I keep this open, then z 1 1 is 1 parallel 5. That is, 5 by 6 ohms, z 2 2 would be 1 plus 3 parallel 3. So this is equal to 1 plus 3 by 2, which is equal to 5 by 2 ohm. 2 point 5 ohms. z 1 2, well I know z 1 2 and z 2 1 shall be the same. Let us find out z 2 1. z 2 1 would be equal to V 2 by I 1 with I 2 equal to 0. Let us calculate this.

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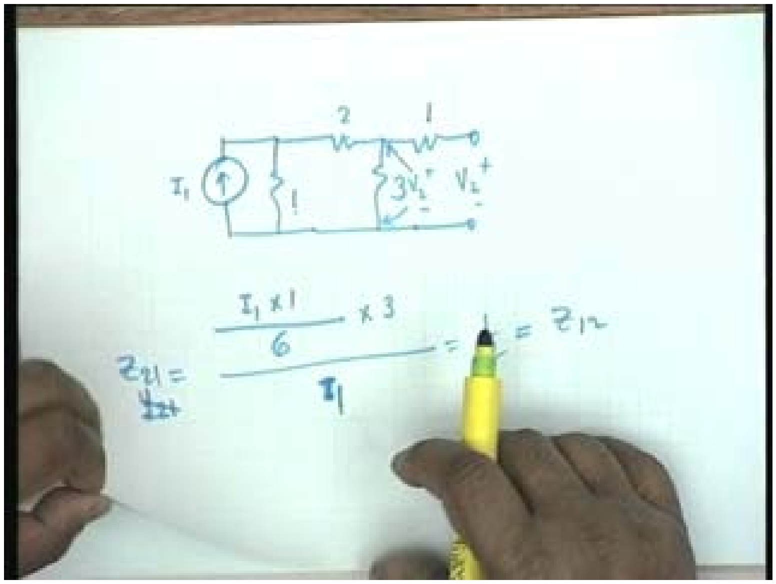

We have an I 1 here, 1 ohm 2, 3 and again 1 and our I 2 is 0 therefore, this is V 2, what is this? This is also V 2 because I 2 is 0. So all that is required is to calculate this voltage and you see how I calculate. The current would be I 1 into 1 divided by 1 plus 2 plus 3, so 6, 6 multiplied by 3, that would be V 2, multiplied by this resistance, that divided by V 1, this will be y 2 1, no that divided by I 1, so it is simply half. I beg your pardon, this is z 2 1, which is equal to z 1 2. Everything done by inspection, I did not have to calculate z 1 2 because I noticed that the network is reciprocal, so they should be equal.

Let us look at the y parameters and see if we can do the same thing, by inspection. So y parameters, let me draw the network again.

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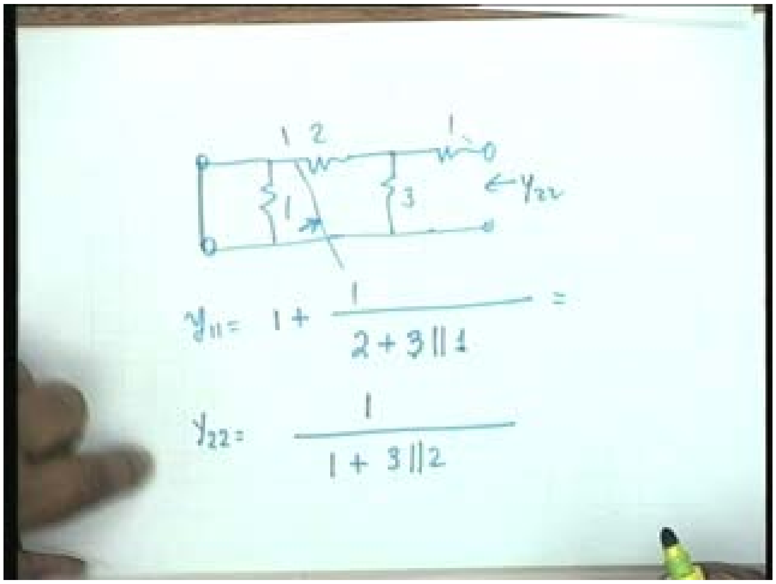

1, 2, 3, 1, for y 1 1, you see we will have to short this. If I short this, then I get 1 plus 1 over this admittance in parallel with whatever admittance comes here, which is the reciprocal of impedance, so 2 plus 3, 3 parallel 1 because this is shorted, 3 parallel 1. Whatever the value is, we can now calculate. Is that clear? Have I done a mistake? No, I have to short circuit this and so admittance 1, I am calculating admittance, 1 plus whatever comes in parallel, admittance.

So it is reciprocal of impedance. Impedance is 2 plus the parallel combination of 3 and 1 and now you calculate. Similarly, y 2 2 would be equal to, you see it starts with the resistance.

Student: Sir wont it be 1 by 2?

Sir: Pardon me.

Student: Sir, if we are taking the admittance would it be 1 plus 1 by 1 by 2 parallel 1 by 4?

Sir: No, you see, I am calculating the impedance looking here. This is 2 plus the effective impedance of 3 and 1 which is 2 plus 3 parallel 1 and reciprocal of that adds to 1. Do not make such mistakes, one has to be careful. That is why it is said nothing is routine here. Similarly, when you are calculating y 2 2, well I have to keep this shorted, so this 1 ohm goes, that it has no effect, and what I have is 1 divided by, why 1 divided by, because 1 ohm comes in by series. So I find the total impedance and take the reciprocal of that, so 1 plus 3 parallel 2, that is it?

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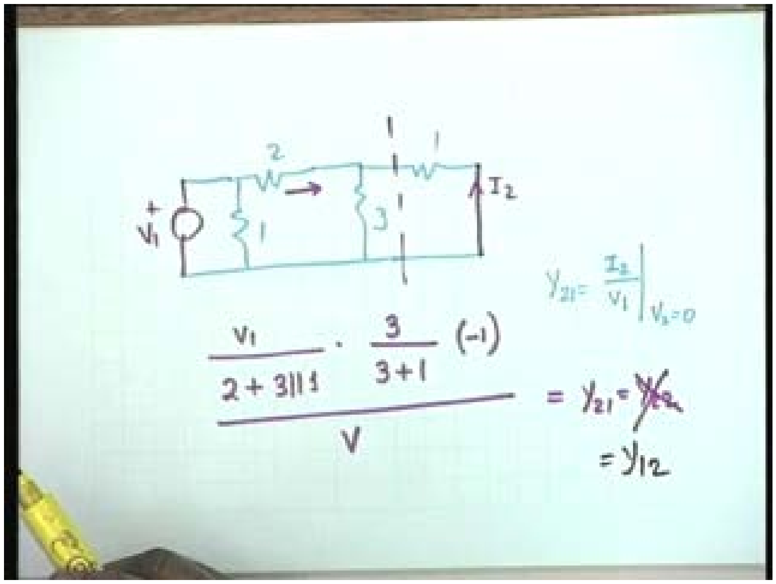

Let us see Y 2 1 and Y 1 2. Once again my circuit is this; 1, 2 then 3 and 1. Let us calculate Y 2 1. Y 2 1 by definition is I 2 divided by V 1, with pardon me.

Student: V 2 equal to 0

Sir: V 2 equal to 0. So I connect V 1 here and V 2 equal to 0. So I connect a short circuit here and this is the current I 2, is that clear? This 1 ohm, obviously, goes out of the picture because it is in parallel with the ideal voltage source so the current through this would be equal to V 1 divided by 2 plus 3 parallel 1 and this current, after going here, divides into 2 parts. So 3 by 3 plus 1, but you have to multiply by minus sign because I 2 does not agree with the sign of this, and this divided by V 1. Now you calculate this will be Y 2 1 equal to Y 2 2. The numerical calculation you can perform.

Student: Y 2 1 or Y 1 2?

Sir: Oh, Y 1 2, I beg your pardon. How can I make such mistakes? One thing that I want to point out here is that you cannot do this by inspection. No way, there is not a single element between the input and the output. There are 2 elements and there is a junction in between, so that pi equivalent circuit or T equivalent circuit could not be applied here, is this point clear?

Student: (..)

Sir: What we could do is, you could calculate the Y parameters of this, by inspection. But these resistance affect z 2 2. It does not affect any of the Y parameters. So it is not a straight forward comparison with the equivalent circuit. You could also say, this T 2 3 and 1, that is a T equivalence, but this 1 affects Y 1 1 not z 1 1, is that clear? So, one cannot apply equivalent circuits here but wherever applicable, you can do that, for example, the 9 2, the second problem.

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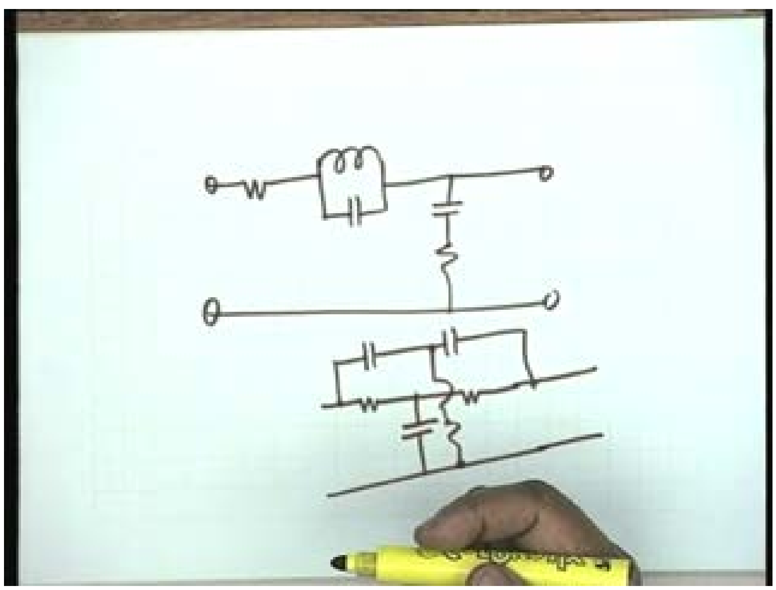

The second problem has this architecture and you notice that it can be solved very easily by either T equivalent circuit or pi equivalent, both are applicable, is not that right?

Student: Yes sir.

Sir: So we will not do this, agreed. The third problem is a bit intricate. Third problem is a parallel T, the third problem is like this. R R C and C C R, to calculate the z parameters and y parameters without looking upon this network, as a combination of 2 networks, obviously, it is a parallel connection of 2 T networks but that does not help unless you unless you apply matrix inversion and this also I should leave to you.

Student: Also, we convert it to pi then make it simple.

Sir: You can convert each of them into a pi.

Student: Sir there will be with 3 parallels.

Sir: 2 parallel pi networks.

Student: Sir, but each one will be individually, all the 3 R should be in parallel with each other so it would be very.

Sir: No I did not understand what you said.

Student: Sir, at the, when we replace each one of them by the pi, each R would be in parallel with respective R of the other one, so it becomes very

Sir: That is correct, so 2.

Student: So it just becomes 1 by net

Sir: 2 pis in parallel become 1 pi. pi parallel pi is equal to pi. Not in terms of numerical numbers, architecture and therefore, I can find the y parameters but that is requires a conversions and I assure you the labour involved is no less than the labour involved in making a node analysis or mesh analysis. It is almost the same amount of labour. One is matrix conversion, the other is matrix determinant and all, both of them require almost the same amount of labor. Howeverm, whatever is convenient to you, it is a personal choice. Some people like blue sweater, some like red. It is exactly that, there is nothing to choose between.

9 3 and 9 4 are very interesting examples and I want you to do this yourself, very interesting example, but very simple. But you have to find out how to proceed, that is about it, you have to figure out. So we will not discuss this. We will go to 9 point 5.

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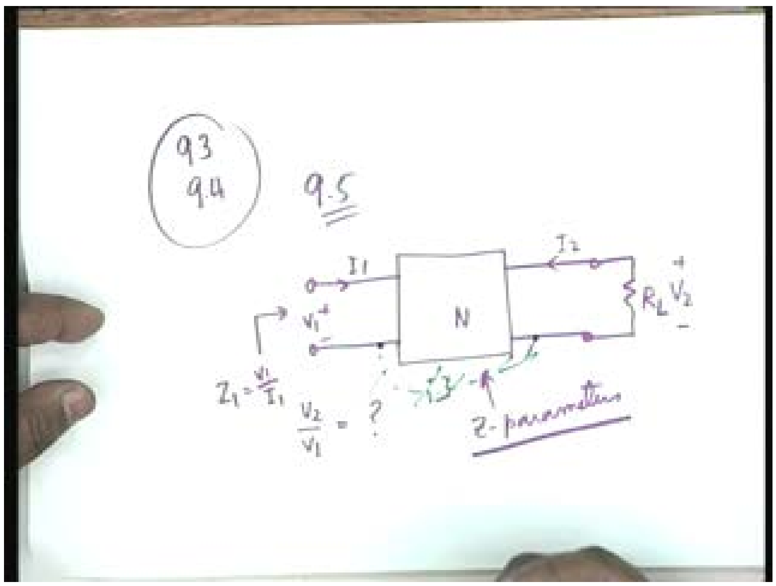

9 point 5, it says for the circuit shown. The circuit is this, we have a network N, it is a 2 port network. Port number 2 is terminated in R L. This is I 2 and this is V 2. This is V 1 and this is I 1. For the circuit shown, you have to find the voltage transfer ratio, voltage transfer function V 2 by V 1 and the input impedance Z 1, which is equal to V 1 by I 1, under this condition. in terms of Z parameters of the network N and the node resistance R L. The problem is a 2 port which is terminated in a resistance to find out the voltage transfer function and the input impedance. Any suggestion as to how to proceed?

Student: (..)

Sir: We write out the 2 equations and then manipulate, any other approach?

Student: Use R l and z 1 1 minus.

Sir: Can i use the T equivalent circuit here, mathematically equivalent?

Student: Rather sir, pi equivalent.

Sir: You want the pi equivalent circuit but the question says you have to work in terms of z parameters.

Student: It is 3 port so the second terminal has.

Sir: When the question says you have to work in terms of z parameters

Student: Sir, we can work in T parameter also.

Sir: So we can work in T parameters. Can we use the T parameter equivalent circuit, T parameter is 3 terminal. What is the alternative? Alternative is to work with the equations. Suppose the network, now mind my words very carefully, suppose the network had a merging element here. Suppose we have something like this. Also, in addition to this R L, there was a bridging element here, from here to here. Could you use the z parameter equivalent circuit? No, because then this element would have been short circuited. There is no such calamity, possibility of a calamity here and therefore, we can indeed use the T parameters.

We can use, but as a said it has to be used with caution. I have given you one situation where it cannot be used. Now let us do it.

Student: In that case we would have used definition

Sir: Let us use the definition and I assure you the labour involved is nothing more nothing less, it is almost the same.

Student: No sir, in that case if there was some element across.

Sir: If there are some elements, then we have to use the definition. Let us use definitions here also, for this example, let us see.

Student: How do you know that (..) short circuited?

Sir: How do you know that?

Student: (..)

Sir: No, you see, this is a truly 4 terminal network. What I was asking is can we analyze this case, by replacing N by its T parameter equivalent circuit. It happens that in this case we can, we can. But suppose, our network was augmented like this, there was another impedance here, then we could not use the T parameter equivalent circuit.

Student: Why can't we assume that the T parameter network (..)

Sir: Oh, because the T parameter network satisfies the terminal equation V 1 I 1 V 2 I 2, that is all that matters, and there is nothing structurally there is nothing to disobey these equations and therefore, we can replace.

Student: Sir, but the basic assumption of T parameter is that,

Sir: Network is 3 terminal?

Student: I 1 and I 2 are short circuited.

Sir: No, no, no.

Student: Second terminal and fourth terminal are short circuited.

Sir: That is correct. Basic assumption is this and as I said this is mathematical equivalence. Now, working with equations and working with the mathematical equivalent circuit should be the same. What I want to want to do is to use the equation and I leave it to you, to use the T parameter equivalent circuit and then verify that the results are the same. Let us look at this, I shall solve this problem by yet another means, a little later, I hope time permits.

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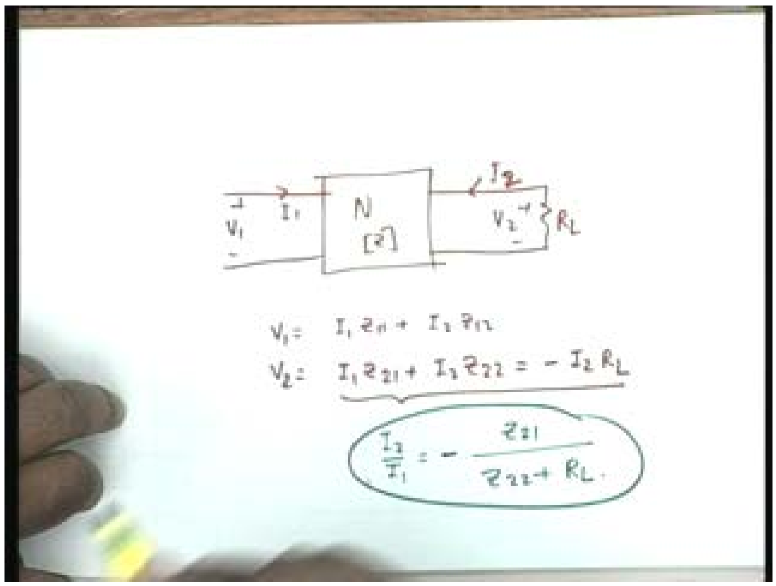

I have the network N, V 1 I 1 V 2 I 2 and there is a termination R L, so I write the equations N has been described by its z parameters, so I write the equations V 1 equal to I 1 z 1 1 plus I 2 z 1 2. There should have been an objection to T parameter equivalent circuit which none of you raised.

Student: Sir, we have to assume the reciprocal.

Sir: You have to use it if you are using a T parameter then you have to assume that the network is reciprocal, which is not given and therefore, in theory there is an objection. So what I want to do is to solve it by assuming the equations and then show that if z 1 2 is equal to z 2 1, the T parameter equivalent circuit is, can output also be used to calculate this. That they give the same results that part, the second part, as I said, I leave it to you. Now, how do you proceed with the equations?

Equations are z 2 1 plus z i 2 z 2 2 and you notice that V 2 and I 2 are constrained by this node impedance. V 2 is simply equal to minus I 2 R L. That is the constraint in equation and if I have V 2, therefore, from this equation you know I 1 in terms of I 2. You know the ratio I 2 by I 1, is that point clear? You do the ratio I 2 by I 1, for example, you see that I 2 by I 1 is equal to z 2 1 divided by z 2 2 plus R L with a negative sign, is this point clear? So I know I 2 by I 1 and if I know I 2 by I 1, then obviously, I know V 2 by V 1. V 2 by V 1 is this divided by this divide by I 1. V 2 by V 1 would be equal to z 1 1 plus I 2 by I 1, z 1 2 z 2 1 plus I 2 by I 1 z 2 2, agreed.
No, I have made a mistake, what is the mistake?

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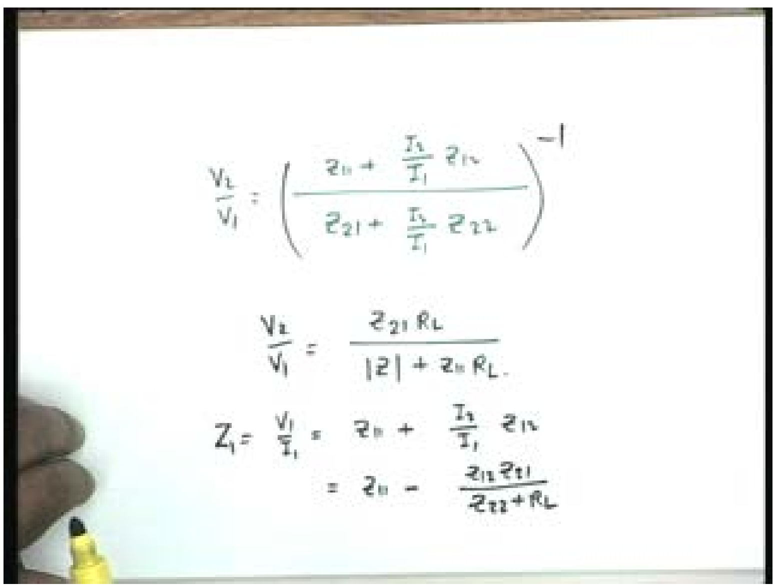

Student: Sir, it is the other way round.

Sir: This is the other way down, this to the power minus 1. You simplify this, I will simply give you the final result. The final result is z 2 1 R L divided by determinant z plus z 1 1 R L. This is V 2 by V 1, after simplification. The other question to be answered is V 1 by I 1. So the impedance z 1, which is equal to V 1 by I 1, obviously, z 1 1 if I take the original equation, V 1 equal to I 1 z 1 1 plus I 2 z 1 2, it will be z 1 1 plus I 2 by I 1 z 1 2, which is equal to z 1 1 minus substitute for I 2 by I 1, z 1 2 z 2 1 divided by z 2 2 plus R L. Oh, this stands for the determinant of z and you see that the determinant of z once again shall come here.

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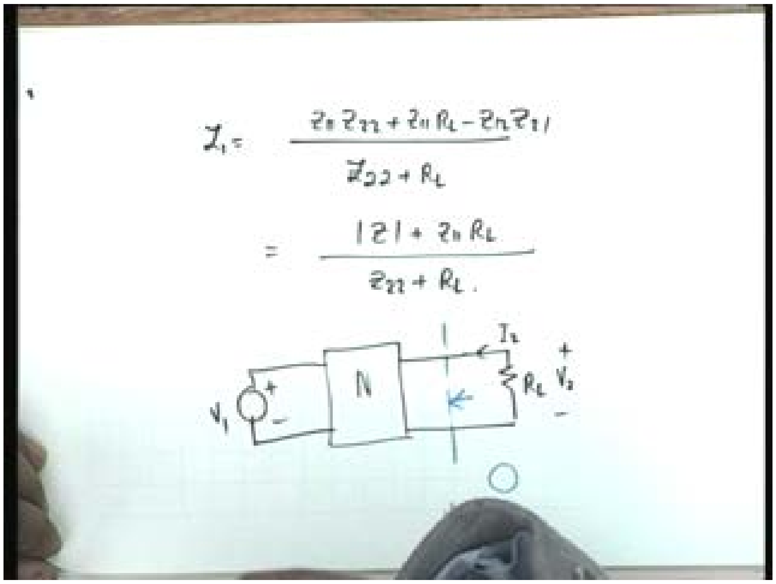

If you simplify this, you shall get z 1 as equal to z 2 2 plus R L then here we shall have z 1 1 z 2 2 plus z 1 1 R L minus z 1 2 z 2 1, which is equal to determinant z plus z 1 1 R L divided by z 2 2 plus R L. I want to go back to this equation.

Student: Sir, instead of dividing V 2 by V 1 , we could have I 2 by I 1 and.

Sir: That is what we have done. That is what we have done, we have not done anything else. We have substituted for I 2 by I 1. I want you to look at it look at this network from a different angle let me draw the network and again an alternative way. What we have is a voltage source here, V 1 and R L, this is V 2 and this current is I 2, an alternative angle of looking at it. Suppose I apply Thevenin's theorem to the left of this. Thevenin's theorem, then what would be the equivalent voltage source? If I keep this open. Pardon me

Student: Sir, V Z 1 2 by Z 1 1 plus Z 12.

Sir: Oh, how did you find that? If I keep this open.

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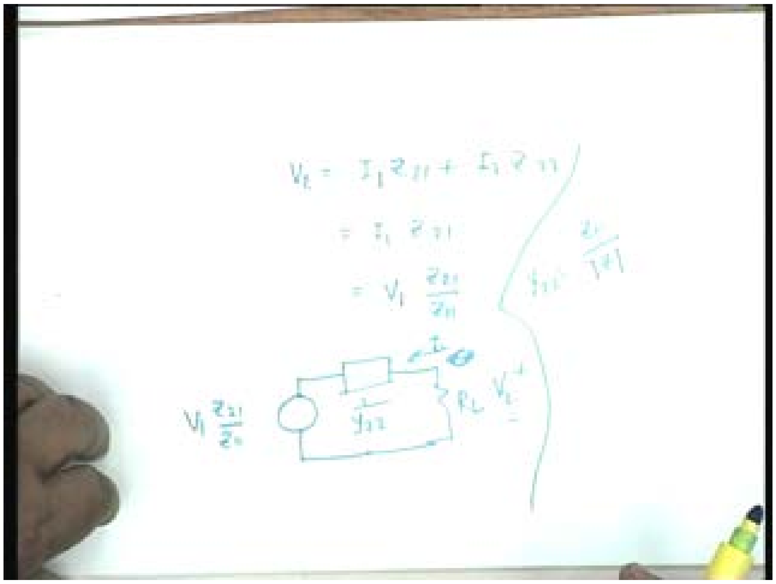

Sir: You see, V 2 equal to I 1 z 2 1 plus I 2 z 2 2. If I keep I 2 open, i 2 0, then this would be equal to I 1 z 2 1.

Student: (..)

Sir: Now what is I 1, under this condition?

Student: V 1 by z 1.

Sir: V 1 by z 1 and therefore, this is V 1 z 2 1 by z 1 1. Is that clear? Is that what you said? No, you said something else. This is it, V 1 z 2 1 by z 1 1. Therefore our equivalent voltage source would have been V 1 z 2 1 by z 1 1 and what would be the equivalent impedance, looking back? Short circuit this, then what is the impedance looking here? Oh, I am sorry, i should show this. You have to look at the impedance looking back into the network, so you short circuit V 1, what would be the impedance, looking back? What is the admittance, looking back? No? You do not understand what I am saying? The 2 port

Student: 1 by z 2 2 plus 1 by z 1.

Sir: No.

Student: (..)

Sir: It is much simpler than that, no. 1 by z 2 2 will be if this kept open. Now we have shorted it. So I know the admittance, the definition y 2 2 is the admittance looking back from port number 2 with port number 1 short circuited and this is precisely what it is. 1 by y 2 2, this is the similar impedance, is it okay? No, it is not clear? What is y 2 2? Y 2 2 is equal to V 2 by, I am sorry I 2 by V 2 with V 1 equal to 0. So V 1 equal to 0, if this is shorted, then the admittance looking here must be exactly Y 2 2, yes?

Student: Yes.

Sir: And therefore, the dividend impedance should be 1 by y 2 2, is that okay?

Student: Sir, will not it be y 2 2 parallel with y 1 2?

Sir: No, nothing else.

Student: Why sir?

Sir: Why because I 2 equal to v 1 y 2 1 plus v 2 y 2 2, right? And if v 1, I am sorry, if v 1 is 0, then I 2 v 2 simply y 2 2, agreed. This is the definition of y 2 2, the short circuit admittance, driving point admittances parameter. It is the admittance looking into the driving point with the other port short circuited. So this is my equivalent circuit then. This is v 2 and this is I 2. The only problem is that instead of all z parameters, that has occurred in y parameters and we shall show, later because the y matrix is the inverses of the z matrix, y 2 2 shall be equal to z 1 1 divided by determinant z and that is how z 1 1 determinant z z 2 1 and z 1 1 will come in the calculation.

Now, it is a 1 loop network, nothing to, you see v 2 by v 1 shall be simply potential division between these 2. The input impedance, oh, that is a problem. Input impedance cannot be calculated from here, is that clear? Input impedance cannot be calculated from here because you have replaced the network to the left of this line. So you have forgotten what is happing at the input. Let me also show you a method of calculating input impedance.

Student: Sir cannot we short circuit v 1? So v 1 will be 0.

Sir: cannot we short circuit v 1? Yes, you are short circuiting v 1 so

Student: So then.

Sir: Input impedance. Input impedance is here at port number 1. I cannot calculate it, but let me show you. It is not required for this particular problem but let me tell you one way of looking at the network. Once again, another alternative way.

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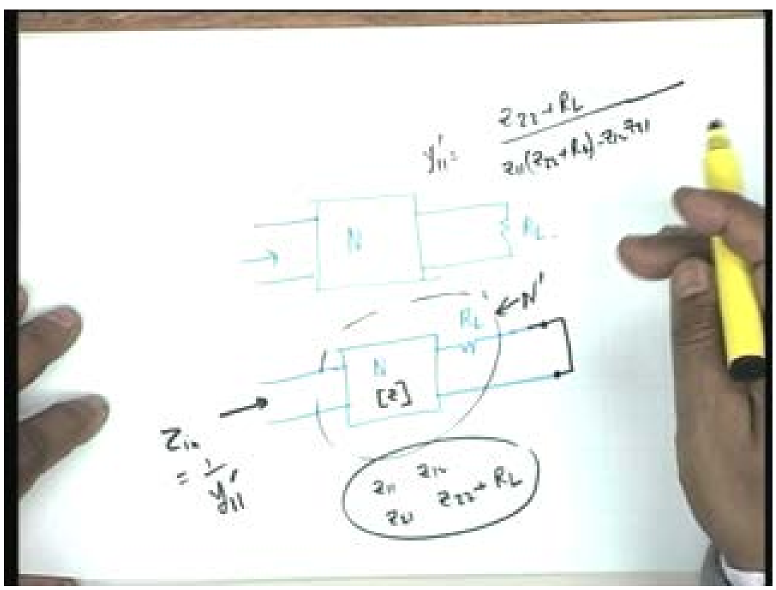

The more ways you have the better equipped you are, but an engineer's job is to find out which method will work best in a particular situation. In this situation, it is not required. But suppose you are required to calculate the input impedance of a network terminated in a resistance and there is no restriction on y parameter or z parameter or whatever it is. No restriction. We find in terms of parameter, then we make substitutions. I can look up on this network, be careful, now what i am doing. No tricks, very simple method. I can look upon this network as an augmented one with an R L at the port number 2 and then the output port is short circuited, is that okay?

Student: Yes sir.

Sir: So these network, this network, what are the z parameters of this network? z 1 1, z 1 2, z 2 1, the only thing that happens is z 2 2 is augmented by R L, agreed. The z parameters of this black circled network, z parameters of N are given by the z matrix and the z parameters of this is this. Now, what is the input impedance? Input impedance is, for the augmented network, let us call this N prime. If, for N prime, which parameter the relates to z input, which parameter?

Student: (..)

Sir: No.

Student: Sir 1 1.

Sir: No. Why? I have a short circuited this. The port number 2 is short circuited, I am measuring impedance port number 1, so z in must be 1 by y 1 1 prime, is not that right? The z matrix is known and I can find out y 1 1 prime. What would be y 1 1 prime? This will be z 2 2 plus R L divided by determinant z, that is, z 1 1 z 2 2 plus R L minus z 1 2 z 2 1, is not that all, agreed? y 1 1 prime would be z 2 2 plus R L divided by determinant of z. So this is an inspection. You do no calculation, nothing, no simplification and many at times, you shall be required to do it. If you cannot figure this out, you will spend an hour over calculation of the input impedance.

You must have all your equipments, all your tools at the tip of your finger nails, if you can. The final problem that we will work out is that of the transformer, 9 point 7. It says find the z and y parameters of the transformer, non ideal transformer, the transformer is this.

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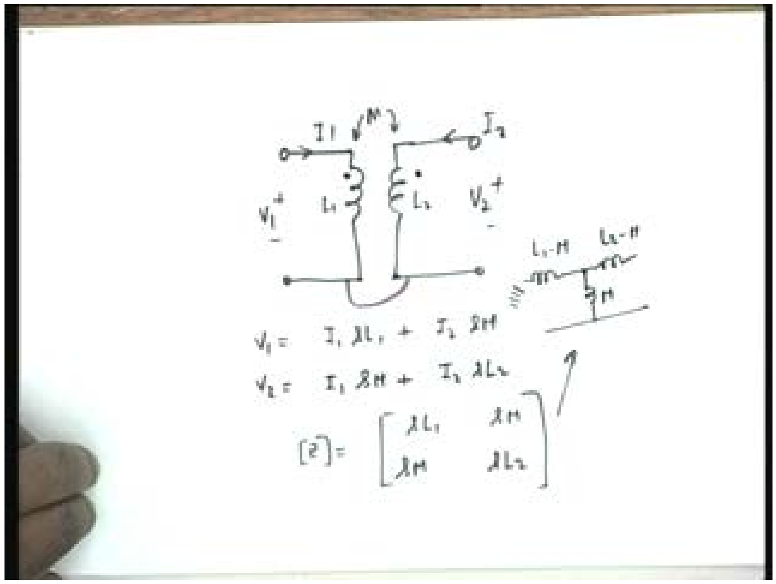

It is not a 3 terminal network. This is the transformer v 1 I 1, it is a truly 4 terminal network, no questions of those 3 terminal equivalents. This is L 1, L 2, dots are here and this is M. It says find the z and y parameters of the transformer shown in the figure, and then it says determine the T and pi equivalent circuits for the transformer in terms of L 1, L 2 and M. Obviously, the assumption is, the T equivalent circuit or the pi equivalent circuit would hold when these 2 are connected to each other, agreed? This is the implicit assumption.

Now the solution, is there any question before I give the solution? Now it is obvious that if you write the 2 equations, I 1 and s L 1 plus I 2 s M, the currents and the dots agree with each other and v 2 equals to I 2 I 1 s M plus I 2 s L 2 and therefore, the z parameters are s L 1 s M s M and s L 2, agreed.

Student: Sir, should e consider resistances also?

Sir: No, there are no resistances given. Non-ideal in the sense, oh, that reminds me. What is an ideal transformer? Why is it called non-ideal? Ideal transformer?

Student: (..)

Sir: Is that the only thing? No.

Student: (..)

Sir: Correct. If k is equal to 1 and the circuit is lossless, no resistances, it is called a perfect transformer, perfect. In addition to perfection, idealness is above perfection. Idealness implies that both L 1 and L 2 tend to infinity, such that, the ratio is finite. This is the definition of an ideal transformer, so this is non-ideal and you see, the z parameters are obtained by inspection and you also know the, if these 2 terminals are connected, that if it is a 3 terminal network, then these z parameters can be represented by the T equivalent circuit.

And the equivalent circuit would be L 1 minus M, z 1 1 minus z 1 2, L 2 minus M and z 1 2 shall be equal to M. This would be equivalent to this, provided this red coloured connection is there. Pink coloured connection. z parameters was simple, how about the y parameters?

Student: If this was no there, we cannot terminate?

Sir: We cannot terminate, because then physically this is not this same as this.

Student: But then mathematically we can do.

Sir: Mathematically is okay. So long as you work with only v 1 I 1 and v 2 I 2. But suppose, this is a 10 kilovolt, the input is, what is this down conversion, 220 kilovolt to 230 volt, at a substation. Suppose, this is 220 kilovolt and it is ungrounded, this is 230 volt and it is grounded and we use this to calculate anything that you want and you actually put your equipment in between these points or you argue between this point and this point. The whole house has had a fuse, if not fire. Fuse will blow if fire cannot catch before this. So be careful in applying, this is why I used a pink colour, I should have used a red, red for danger. The problem now is to how to find the y parameters?

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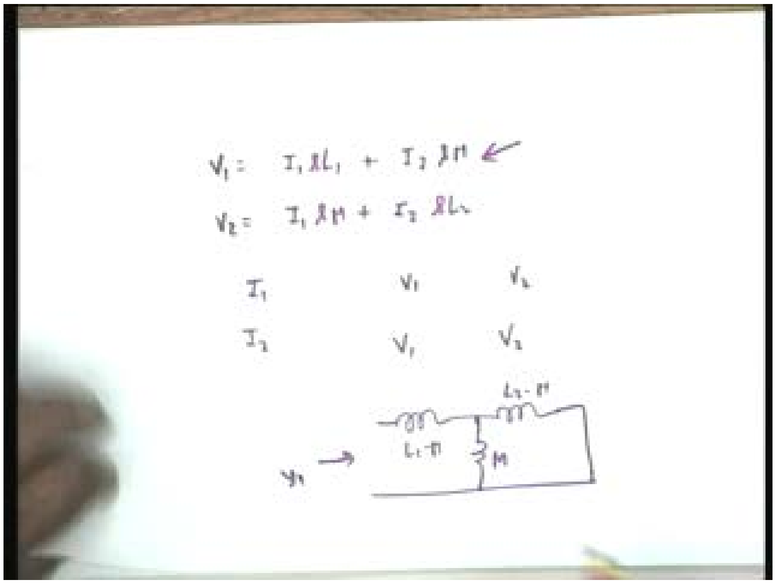

How to find the y parameters, and I, let me tell you if you want it do it ab initio, then there is nothing better than using this equations. After all, what does finding y parameter mean? What does finding y parameter mean? It means that you express I 1 and I 2 in terms of V 1 and V 2.
so what you do is, find I 1 from here in terms of v 1 and I 2 and substitute here. From one of the equations, find I 1 in terms of I 2 and V 1 and substitute in the other equation. That should be simple enough. This is one way, this is one way.

The other way is, you can, in this case, apply the T parameter equivalent circuit and apply definitions of the y parameters. For example, if I want to find out y 1 1 L 1 minus M, I am only doing mathematical calculation, nothing else. L 2 minus M and M. Suppose, I want to find out y 1 1, then I have to short circuit this. So I can calculate y 1 1.

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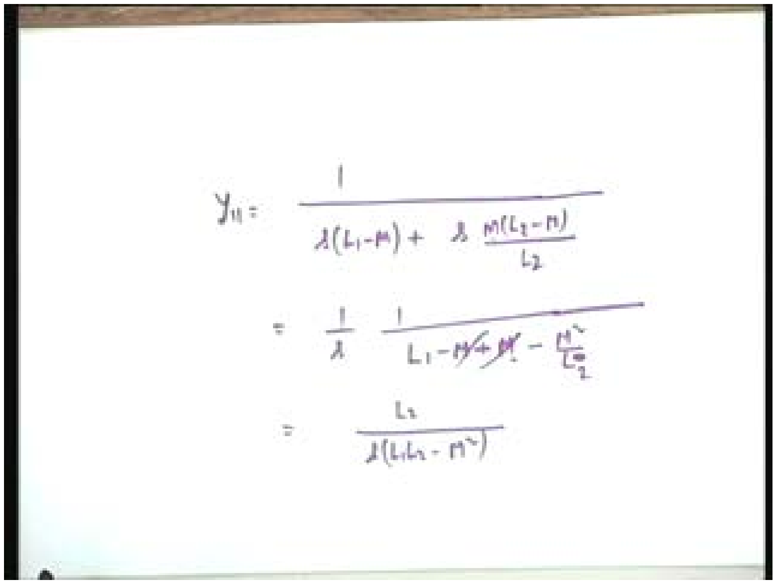

By inspection, y 1 1 shall be equal to 1 over s L 1 minus M, why 1 over? Because I am calculating the impedance, plus the parallel connection of M and L 2 minus M, which is obviously s M L 2 minus M divided by L 2. The parallel connection of 2 inductances L 1 L 2 divided L 1 plus L 2 and since M and L 2 minus M, therefore, this is 1 over s 1 by L 1 minus M plus M minus M square by L 2, agreed. Or is the simplification too fast? I have taken S out from both M L 2 by L 2 is M and M squared by L 2, M squared by L, so this M and M cancels and you can see that this is L 2 divided by S L 1 L 2 minus M square.

If this was a perfect transformer, what would have happened? y 1 1 would have been infinity. In other words, the perfect transformer, the y parameters are not defined. Similarly, you can find the other 2 parameters and I repeat, in this case, you can apply the T equivalent circuit, to derive the y parameters because that is, it is a limited objective, but do not dare to do anything else because you might destroy whatever, your transformer and also whatever you connect to it. That is all for today.