Network Analysis
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Lecture – 73
Two Port Network - III

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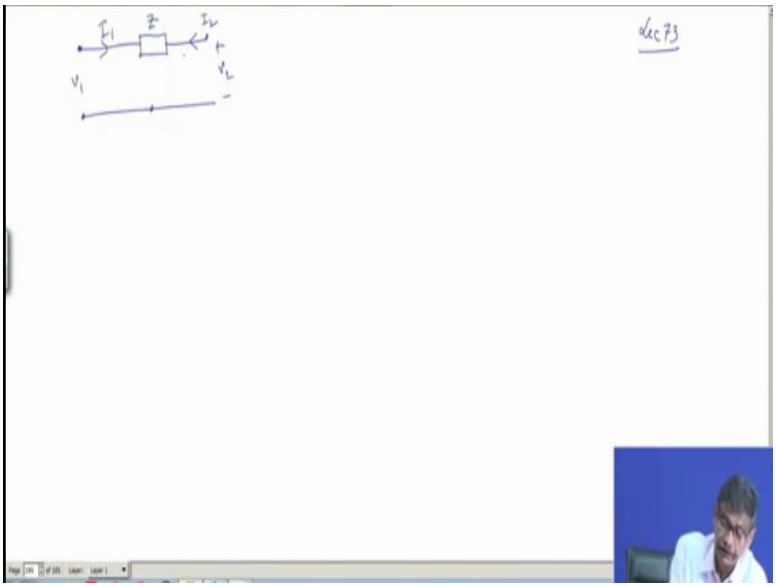

So, we were discussing about 2 port network and one example I took that if the network; the 2 port network is known to be as simple as this, this is the 3 terminal port, number of terminals are 3 but input port are these 2, there is a common terminal, so this is V1, this is I1 but I should not play with the polarities that we have assumed to be consistent all the time, so this is how a 2 port network is defined.

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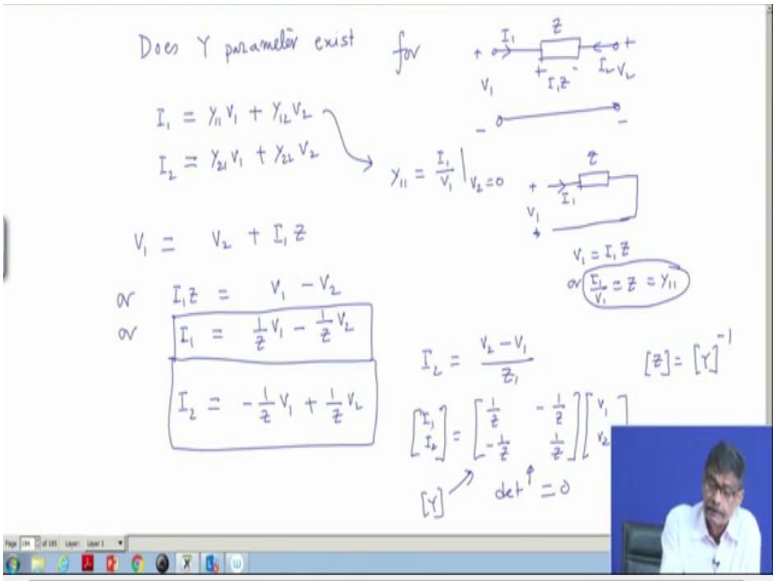

And then we found for this network, Y exist that is what I did for this network I found, y parameters can be easily found out instead of doing like this, you can because it is such a simple network you write down these equations and cast it in this form I1 in terms of V1, V2 I2 in terms of V2, so y parameters exist but then z parameters; if you wish to calculate z parameters you must take the inverse of this Y matrix.

This is the; this one is the Y matrix, is it not and we find determinant is 0, you have to divide all the elements with determinant 0, then the all the elements will blow up to infinity and it is of no use to us. Another example let us take, so this one we have considered now, another simple example let us take.

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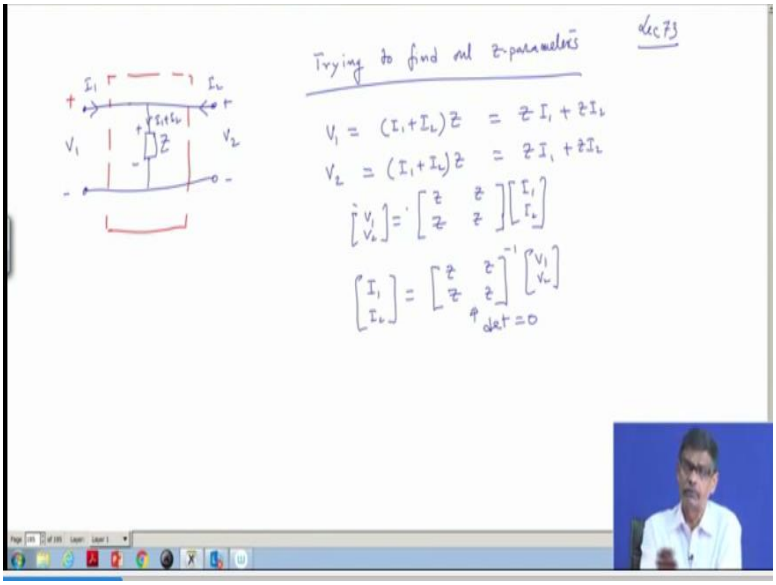

For example, this you delete this one, so let us take another example suppose, a simple example it will give you more, better understanding what really we are doing suppose, you have a network like this, I tell you it is and the 2 port network is known suppose, I say there is an impedance between these 2, this is no z parameters, it is the network itself; 2 port network, here is this thing.

And suppose, I know inside it is Z, I tell you and I ask you find out the z parameters, comment on z parameters and about y parameters, you see this one is the convention I1 and this one is the convention of the 2 port network, this I will be always maintaining like this and I want to trying to find out z parameters of this network and to do this, you can go from the definition that write down V1 Z11 but it is such a simple circuit.

I will do it in a much simpler way for example, if this is I1, this is I2, this current must be I1 + I2, is it not and then I will say that the V1 is nothing but I1 + I2 into Z, is it not, the voltage drop across Z is I1 + I2 into Z. Similarly, V2 is equal to also I1 + I2 into Z what else, I1 + I2 into Z and this one is Z into I1 + Z into I2 and this one is Z into I1 + Z into I2, so V1 V2 like this if you write in a matrix form, yes impedance matrix is very much present.

And which are Z, Z, Z, I1, I2, is it not and after I have got this, is it possible to express I1, I2 in terms of impedance matrix, in terms of the voltages, then what you have to do; ZZ inverse into V1 V2 and I find the determinant of this impedance matrix is 0 and therefore, y parameters do not exist that is the thing I wanted to tell you, depends upon; see the arriving at the particular parameter, so whether it is Z or Y, if you can look at the networks, which is very simple in nature, you can just by inspection straight away get it.

You need not do all the time V1 by I2, V1 by I1 with V2 equal to 0, draw the circuit gate, those things are not necessary as it is so simple in types, in fact if you are very good in circuit you can easily make it out. So, this is the z parameters and y parameters I have talked about.

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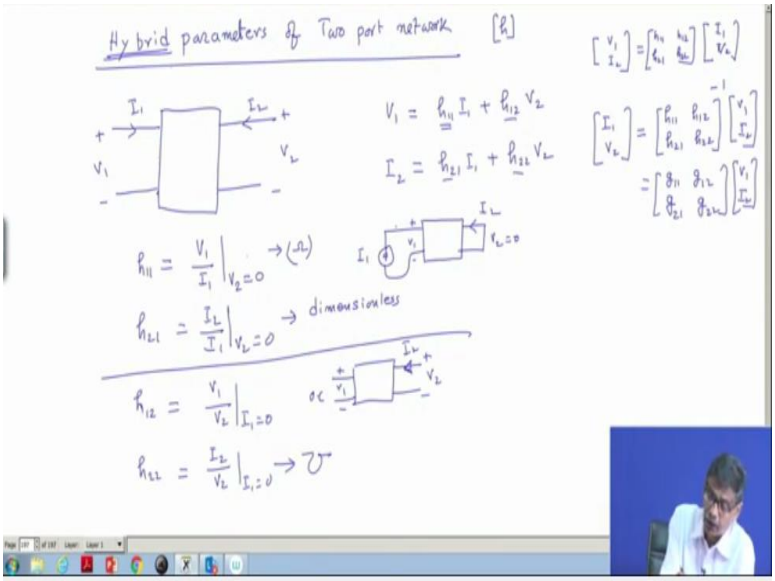

Now, there is another parameter called hybrid parameters and hybrid parameters of a 2 port network, is it not, so here what is done is these hybrid parameters of this 2 port network are denoted by h matrix, now what it is? It also delayed suppose, a 2 port network is there like this and here is your same convention V1 I1 and V2 I2, same network and this can be written in terms of impedance parameters, it can be expressed I1, I2 can be expressed in terms of admittance parameters.

Similarly, those are the basic equations, if we try to write down these quantities that is I will express V1 as a function of I1 and V2 and this is h21 I1 + h22 V2, mind you these are algebraic equations I can manipulate them in this way and can express it V1 V2 in terms of I1 I2 or I1 I2 on one side and V1 V2 on the other side, then admittance parameters and therefore, people say that okay it is not you take voltage of input port and current of output port.

And try to express it in terms of input port current and output port voltage and then I will call these parameters like this, so this is another way of one can express a same 2 port network either in Z or in Y or so called in the hybrid parameters. Now, whether those parameters value will exist or not, we have seen how to also ascertain that but right now, if it is what is the implications of these parameters, let us try to examine.

For example, under this condition that is I want to write down the input voltage and output current in terms of some parameter values there, in terms of I1 input current and output voltage, a mixed up thing, voltage and current accha, let us see what happens to h11, what will be h11; h11 will be V1 by I1 with V2 is equal to 0, this is what it will be, V1 by I1 with V2 is equal to 0.

How to find this out; that is take the network, same network with which I should excite it I1, a current source, I have excited I1 and then V2 is equal to 0, means it should be shortened, is it not, V1 by I1 with V2 equal to 0 is h11, therefore this V2 equal to 0 you make and record this voltage, then V1 by I1 is h11 parameter, it will be h11 will have a unit of omega means ohms, V1 by voltage by current.

Is it equal to the driving point impedance of the z parameters that we will see and you can easily ascertain but let us keep, so h11 is this, similarly h21 from the same network with V2 equal to 0 will be equal to I2 by I1 from the second equation; I2 by I1 with V2 equal to 0 that is do this experiment, short circuit the output ports, excite it with current source and record the current gain I2 by I1, h21 is dimensionless.

In fact, current amplification sort of thing I2 by I1, it tells you about that when the secondary shorted similarly, so this is h11, h21, what is h12; h12 will be equal to V1 by V2 with I1

equal to 0, is it not, if you make I1 equal to 0, then V1 by V2, so what experiment you have to do; you excite the second port, output port with a voltage V2, you excite this current is I2 but keep this open circuited, I1 is 0, OC; open circuit.

And record this voltage V1 by V2 under this condition, h12 will be also a dimensionless quantity, it tells you the ratio of the voltages of input and output port and from this you can also find out from this experimental setup, you can find out h22 also, h22 will be equal to I2 by V2 with I1 equal to 0 that is from this experiment only, so you measure this current I2 and V2 with I1 equal to 0 open circuit.

This will be the; it is not a dimensionless quantity, it is more conductance 1 over ohm, therefore you see it is a mixed up thing, all the parameter values are not having same dimensions sometimes current gain, sometimes voltage gain and so on but nonetheless it can be done, okay and so this equation is therefore, h11 h12 h21 h22 and if you wish the inverse relationship can be also written like this; I1 V2 that is input port current.

And output voltage; port voltage can be also written like this, h11 h12 h21 h22 and its inverse into V1 into I2. If this inverse exists the and these parameters are called; we will not discuss in detail are called the inverse of h parameters that is h21 g21 and g22, in the same way as we have we can find out the y parameters from z parameters and so on and I can easily write down that expression which I am not going to do, you have understood this from the previous knowledge.

Therefore, this is the scenario of the h parameters representation of a 2 port network, now the question is when to use representing a 2 port network which one will be convenient; z parameter, y parameter or h parameter now we know, it depends upon the situation, right now I am not telling that but these are the various combinations that input voltage; input port voltage and input port currents and output port voltage and output port currents can be expressed, after all these 2 are simple, linear algebraic equations, okay.

After I have done this, let me also tell you about another and this is called h parameters, so far 3 parameters; z and y parameters and h parameters, these are extensively used by while solving networks with transistors, h12 is beta things like that, we will see to it later if time permits.

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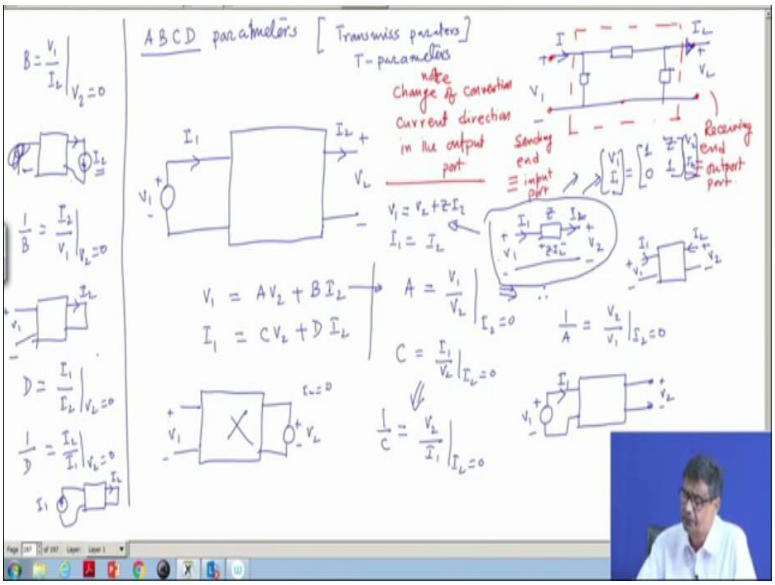

Now, another way of representing a 2 port network is done by what is known as ABCD parameters and sometimes it is some transmission line parameter; transmission parameters or simply written T parameters. Why it is called transmitted parameters will be apparent, see suppose you have a 2 port network okay, what happens is this first you suppose have a transmission line.

Transmission line will have capacitances in parallel, then inductances in series and a pi representation of transmission line could be like this, this is your sending in voltage, this is your sending end current and this is the receiving end voltage V2, after this power is transmitted through the transmission line, output voltage is V2 and this is a typical say, representation of a transmission line, pi representation, there may be T representation also.

But I am just to explain the things I have considered a pi network transmission line modelling, now so these 2 are the input ports receiving sending end and these 2 are the receiving end port; input port, output port but output port is the receiving port, okay and this is the sending end which is input port and this is the receiving end, which is the output port of the network.

Here also, it is 3 terminals essentially, 1, 2 and 3; 3 terminal 2 port network, anyway so this is the thing but here in transmission line business, what people are interested here is a little difference in the convention, what is that convention is that while describing this current

direction, it is taken in opposite I2, so far you recall that I while describing the z parameters, y parameters, h parameters, I always took this to be the current directions.

And this to be the polarity of the potentials of the input and output port is it not but here in this transmission line modelling, ABCD representation of a 2 port network what is done; I2 is taken to be the current delivered, delivered to the load, here what will be there, there will be some load after you receive the power, it is just coming here and that is how ABCD will be defined.

So, you should be just very carefully noting what I am telling now, so it is with this convention, so there is a change of convention for ABCD parameters change, note; change of convention of current direction in the output port and then therefore, while describing the network parameters in this form, what I will do but for z, y and h parameters it was all same, I1 and I2 entering into the port.

But here what we will be doing, this side remains same, this is V1 and this side this is V2 and instead of I2 coming, I will write like this clear, this is the convention for ABCD parameters and then what is done is here that input voltage and output voltage and current are expressed in terms of input voltage and current or input voltage of current that is V1 is expressed as V2 I2, sorry AV2 sorry, it is V1 is equal to AV2 + BI2.

And input current I1 is equal to CV2 + DI 2 and here I will write all positive here and ABCD parameters are defined, alternatively some people do like this okay, this is I2, minus I2 they will write and follow the convention, I will be following this okay. So, for ABCD parameters recall that I2 is to be taken outside, then ABCD are defined in this way, so this is the thing, so input voltage and currents are expressed in terms of output voltage and output port currents as a linear combination.

And this is the way it is, okay now, after we decides that I will write it in this fashion, then we can define ABCD, how to find out ABCD parameters of this 2 port network which is a suppose, the transmission line, okay. Now, let us see what is A; let us try to understand, A is equal to V1 by V2 with I2 equal to 0, from the first equation, if you somehow maintain I2 is equal to 0, then A will be V1 by V2 and with I2 equal to 0.

Similarly, C will be I1 by V2 with I2 equal to 0 now, suppose I want to do experiments and find out in this way, this equation tells me to do. So, what I will be doing; I will take this network and V2 I have to apply that means, here I have to apply a voltage V2 and record this current and input this voltage whatever below I have to excite with that, that is what we have learned from earlier, okay.

But then there is a problem, you see you apply a voltage and still make I2 equal to 0 is very difficult how? So, what people do is this; this point needs some understanding from your part, the way how to apply a voltage and still claim that I2 equal to 0 with that is all I mean, it is difficult but then what I can do is this, from this I come to know okay, what is 1 over A? 1 over A will be V2 by V1 with I2 equal to 0.

Here lies the clue here, therefore in this way it is not possible to find out the value of A but it tells you that okay, 1 over A is V2 by V1 with I2 equal to 0, so this suggests that you take this 2 port network, excite it with V1 voltage with I2 equal to 0, open circuit the other port and measure this voltage and take the ratio of V2 by V1 but it will not give you A but reciprocal of A.

But anyway, once I know 1 by A can be found out, you got the interesting point here, therefore A from this it tells me that okay, V1 by V2 with I2 equal to 0 and so, I will apply a voltage V2 to the output port and I have to measure this voltage V1 but I am not sure what to do because V2 applied I2 may not be 0, how to carry out these experiments but from this we say that 1 over A is V2 by V1 with I2 equal to 0.

And then I am comfortable okay, this is the 2 port network, apply a voltage V1, I2 equal to 0 you are demanding, so keep it open circuited and I can measure this voltage V1, this voltage V2 take the ratio similarly, you see this C instead of trying to do 1 by C is nothing but 1 by C is V2 by I1 with I2 equal to 0, so from the same experiment I will be able to calculate 1 over C that is V2 divided by also record this current I1, is it not.

Same is the case with B parameters, how to find out B parameters let us use this space, on the same page let it be, how to calculate B and D? B as it is B will be equal to V1 by I2 with V2 equal to 0 and so if you want to do what this tells you that take this 2 port network, excited

the output port with a current I2 like this because I2 direction is like this for 2 port network, I mean transmission parameter, so this is your I2, excite it with I2 and V2 is equal to 0.

So, here once again, the confrontation comes, you are connecting a current source between these 2 points of known value I2 and I am not sure whether this voltage will become 0 automatically, difficult to achieve. So, what I will say then that 1 over B same equation, this get reciprocated I2 by V1 with V2 equal to 0 and then it is very convenient okay, what this tells you that okay, take the network, excite it with this V1, V2 equal to 0, short-circuit this.

And record this current everything is fine, so I2 by V1 take this ratio but this is not B, it will be reciprocal of B and then B can be found out finally, the parameters D in the same way it can be calculated, how to find out parameter D; D parameter will be is equal to I1 by I2 with V2 is equal to 0, here once again if you excite this with a current source I2, you cannot be sure that V2 will be 0, how to do this experiment no, difficult.

So, 1 over D is how much; 1 over D is I2 by I1 with V2 is equal to 0, let us calculate that and this is achievable, so what it says that you excite the input port with a current source I1 that is what it says, short circuit these secondaries, V2 is equal to 0 and record this current and the ratio of I2 by I1 is going to give you reciprocal of D, hence D can be found out, got the point and also note that D will be dimensionless, just looking at the ratios B will be that of impedance V1 by I2 something and so on.

So, it is also a mixed up situation but the only thing is input parameters very logical thing okay, input voltage and input port current will be how much if I know V2 and I2, so this is how the ABCD parameters will be found out and I will request you to find out as I have taken earlier if the transmission line is this simple and in the next class, we will discuss suppose, this is V1, this is a transmission line.

In case of transmission line, I will denote I2 to be like this, this you please remember and this is I1, suppose the internally the impedance network is known, then what should be the ABCD parameters, that is what I want to find out. Now, to find out the ABCD parameters of this network you need not do all these shorting these that, you try to see that first thing is V1 for this network, what is V1?

V1 this voltage will be nothing but V2 + Z into I2, is it not, this will be V1, V1 is equal to V2 + Z into I2 one equation is obtained. What is the second equation? I1 expressed in terms of output voltage and output current, what will be I1; same as I2 nothing else, so ABCD parameters of this simple network will be simply like this V1 I1 and here if you write V2 I2, what will be the thing?

V2 into 1; 1 will come here, Z will come here, there is no V2 in the second side, this will be the ABCD parameters of the simple transmission line, yes one could do thought; think in this way and find out but for simple networks, you can easily make it out how the parameter values will look like, we will continue with this in the next class, thank you.