Circuit Theory

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Lecture 26

Two-port Network Parameters: Interrelationships and Applications

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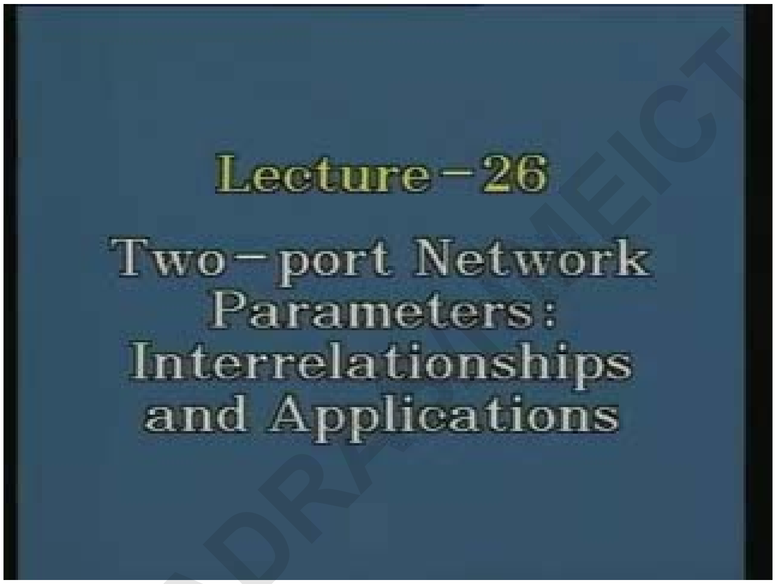

this is the twenty sixth lecture and we are continuing our discussion on two port network parameters

today's topic would be interrelationships and applications of two port parameters

before i take the interrelationships we would like to work out a couple of examples on ABCD parameters and one of them is the ideal transformer

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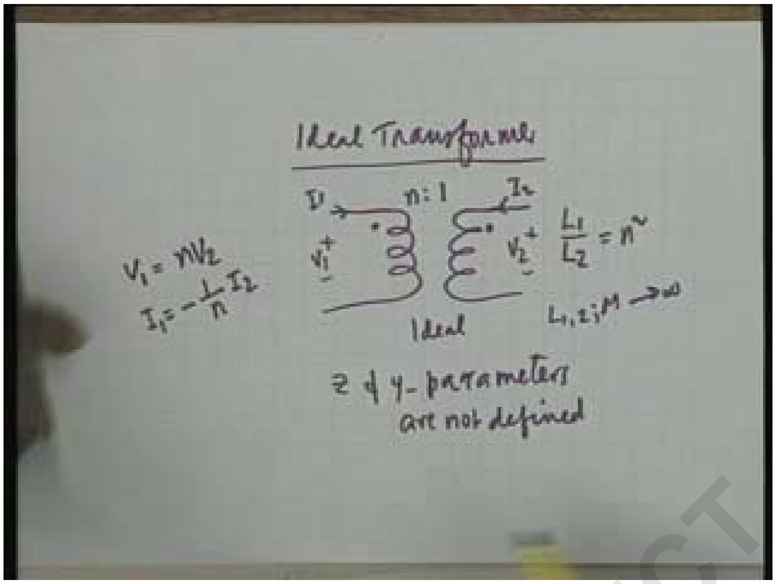

as i have already discussed an ideal transformer has primary as well as secondary inductances going to infinity

the mutual inductance also goes to infinity but the ratio of the two inductances is is finite and this ratio in terms of trans ratio is equal to what L one by L two

do you know the relation between inductance and number of terms inductance is proportional to

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square so this is equal to n square square of the number of terms okay

that is why the ratio is finite because the ratio the number of terms is finite

and in addition we indicate the dots and we write the word ideal here okay in addition to inductance is being infinite the coefficient of coupling has to be one exactly one

if the inductances are finite and the coefficient of coupling is one we call it a perfect transformer a perfect transformer becomes ideal if L one L two and M all go to infinity in such a manner that the ratio of L one to L two is finite okay

now as i have already pointed out an ideal transformer does not have impedance or admittance matrices impedance and admittance matrices cannot be defined for an ideal transformer because z one one is infinity so is Y one one okay

y two two of course z two two also yes correct and therefore z and y parameters are not defined [Noise] are not defined now if i take the voltage current relationships you will see that port h parameters and ABCD parameters can be defined

the voltage current relationships are that V one is equal to n times V two and I one is equal to minus one over n I two this is the relationship

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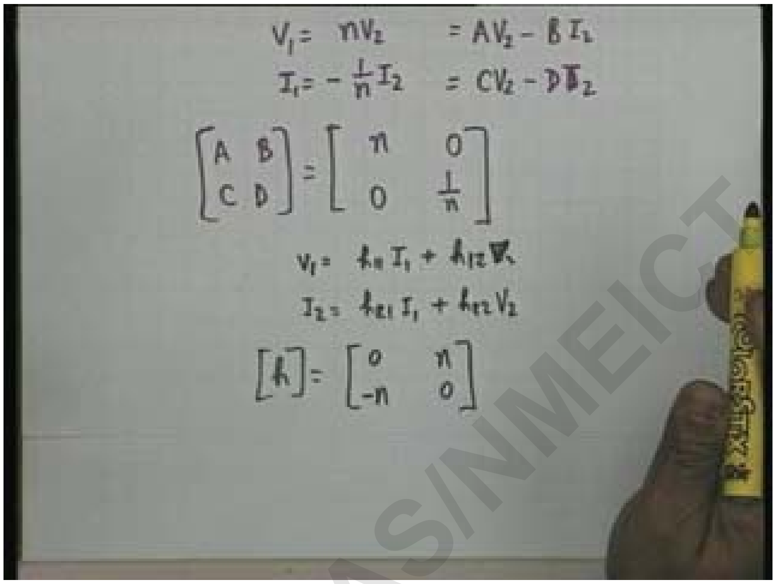

now [Noise] let me write it down again V one equals to n V two and I one is equal to minus one over n I two from which the ABCD parameters are obvious

you see for ABCD V one is to be identified with AV two minus BI two and I one is to be identified with CV two minus DI two agreed

this is the definition of ABCD parameters and therefore for the ideal transformer the ABCD matrix is simply if you compare this with this you see [Noise] that A is simply equal to n B is zero C is zero and D is

<a_side> one over n <a_side>

one over n and you also notice that AB minus CD is equal to one

this has to be obeyed because the ideal transformer is a reciprocal device all right

if i want the h parameters okay the definition of h parameters are that V one is h one one I one plus h one two I two

<a_side> sir V two <a_side>

V two agreed h one two V two and I two the other current is equal to h two one I one plus h two two V two

so can you tell me what is the h matrix now h matrix if you compare these relationship with this you see V one h one one would be zero h one one is zero h one two would be equal to n agreed h two one

<a_side> minus n <a_side>

minus n and h two two would be

<a_side> zero <a_side>

zero and you notice that h one two is indeed equal to minus h two one which is the condition for reciprocity

so if you write the voltage current relationship at the port if you are able to do that a parameter should be obvious and for an ideal transformer the only way to describe it is either an h matrix or an ABCD matrix transmission matrix z and y parameters do not exist

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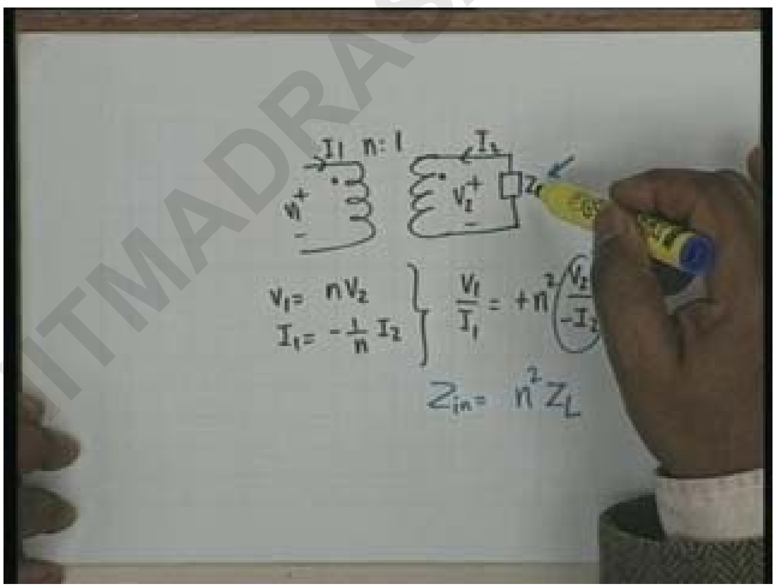

now take an ideal transformer [Noise] and understand why it is called a transformer if i have an impedance z L here the voltages are V one I one V two I two if it is terminated in z L and the ratio is n is to one these are the dots then V one is equal to n V two I one is equal to minus one over n I two and therefore the input impedance V one by I one is simply equal to minus n squared V two by I two now if i transfer this minus sign here then obviously V two by minus I two is equal to z L and therefore input impedance z in is equal to n squared z L [Noise] and this is Y it is called a transformer not only transforms voltages and currents V two is one by n times V one current I two is equal to minus n times I one it transforms voltages and current it also transforms the impedance

the secondary impedance z L is transformed into n squared times z L when referred to the primary

for example if this is an inductance then if it is the inductance L then the effective inductance looking at the primary shall be n squared times L

if this is a capacitance C then the effective capacitance looked at from the primary would be C divided by n squared if it's a resistance R then it would be n square times R this is the property of a transform [Noise]

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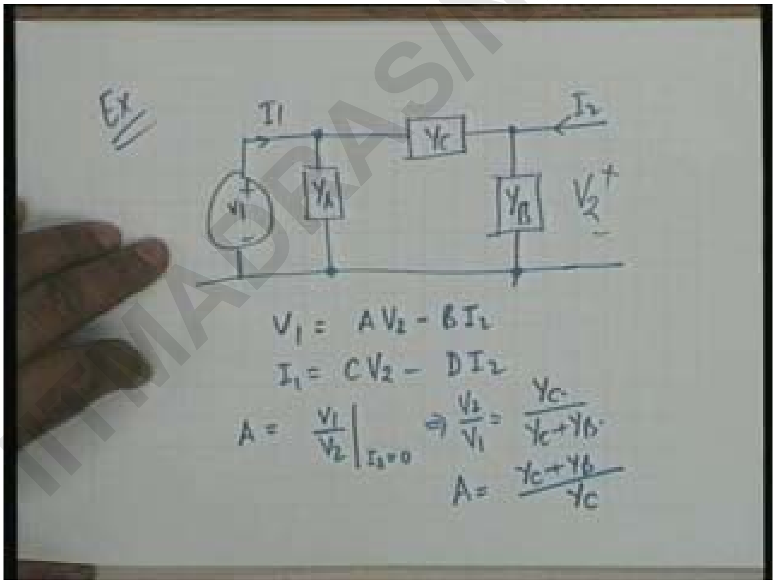

the other example that i take for ABCD parameters is i don’t know if i have done this the pi network have i done this ABCD parameters or did i derive the h parameters h we derived

let's derive the ABCD parameters [Noise] V one I one V two I two we wish to derive the ABCD parameters our relationships is V one equal to AV two minus BI two and I one is equal to CV two minus DI two all right

A is equal to V one by V two under the condition I two equals to zero and therefore what i do is i keep this open connect a source here connect a source here this is a constraint because i two equal to zero i connect connect a source here all right this i have explained already

so what you have to find out is V two by V one and then find the reciprocal of this so under this condition V two by V one V two by V one would be a potential division YA is ineffective potential division between YC and YB and you can easily show that this is YC divided by YC plus YB okay

in terms of impedances it is z B divided by z B plus z C in terms of admittances it is YC divided by YC plus YB and therefore A is equal to YC plus YB divided by YC is that okay

this is the value of A [Noise]

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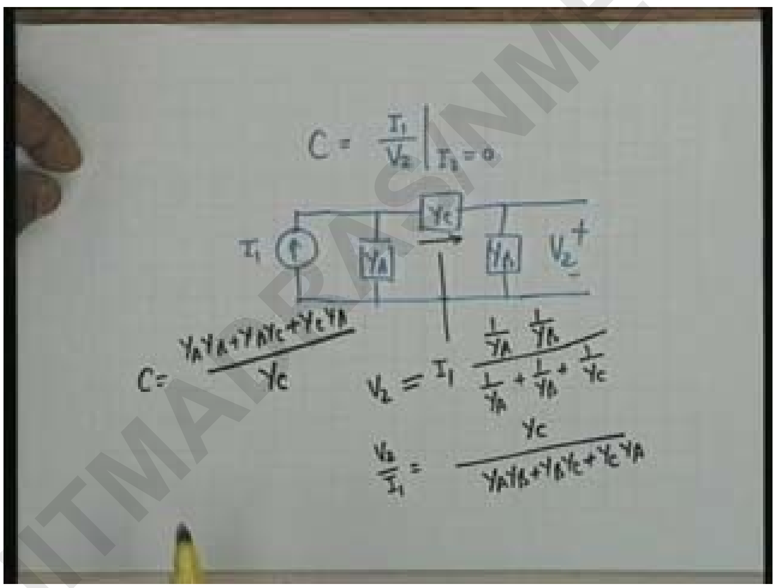

to find the parameter B well i can find another parameter from the same network you notice that C is equal to I one divided by V two with I two equal to zero [Noise] so i can find out C by connecting a current source I one to the network YA YC YB and then finding out the voltage here with I two equal to zero this is open circuited

now[Noise] this can be very simply solved this current this current is equal to I one multiplied by one by YA divided by one by YA plus one by YB plus one by YC is that okay

this is this current current division between YA and YB in series with YC and the voltage V two [Noise] the voltage V two then shall be equal to this current multiplied by one over YB and therefore V two by I one is equal to V two by I one is equal to YC divided by YA YB plus YB YC plus YC YA is that okay

are the steps all right i have done it by inspection and therefore C which is the reciprocal of this C would be equal to YA YB plus YB YC plus YC YA divided by Y sub C this is the z parameter

to find the B and D parameters B and D parameters we have to make to V two equal to zero [Noise]

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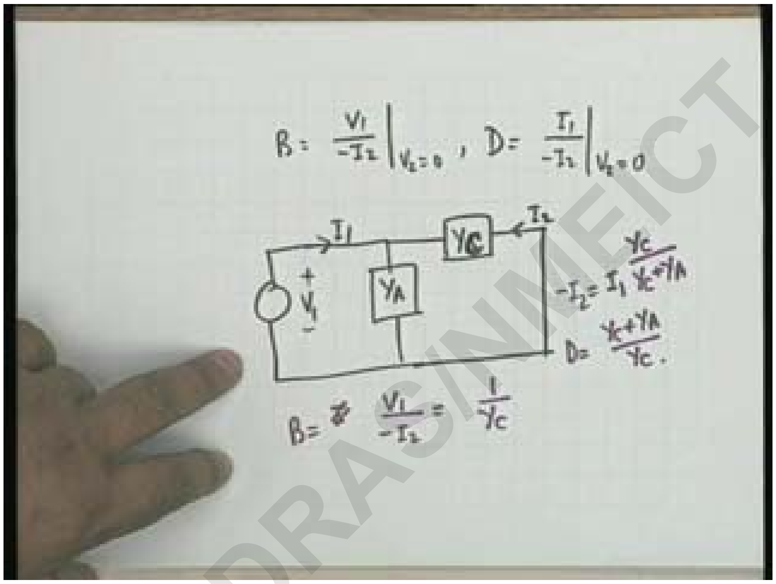

if you recall B is equal to V one by minus I two with V two equal to zero and D is equal to I one by minus I two with V two equal to zero this is the definition [Noise] and therefore i make V two equal to zero which means that YB goes out of the picture

so we have a YA i don't care what this source is obviously we require two sources we require voltage source and the current source or a current sources i don't care what the sources is all i know is this voltage is V one and this current is I one

then you have an YB and it is short circuited YC short circuited so this current must be I two all right

the first thing to find out is V one by minus I two which is obviously

<a_side> that should be YC on the top <a_side>

on the top it is YC correct [Noise] this is YC okay

so what is ah V one V one by minus I two obviously this is equal to one over YC are the signs all right

V one appears across YC the sign I two opposes V one and therefore the negative sign is taken care of and this must therefore be B

as far as D is concerned D is I one divided by minus I two now [Noise] minus I two is obviously equal to I one times yes YC divided by

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isn't that equal to this

<a_side> yes <a_side>

okay i just skipped one step and therefore D is equal to I one by minus I two so it is YC plus YA divided by YC all right i have found out all the parameters

let me let me write them down

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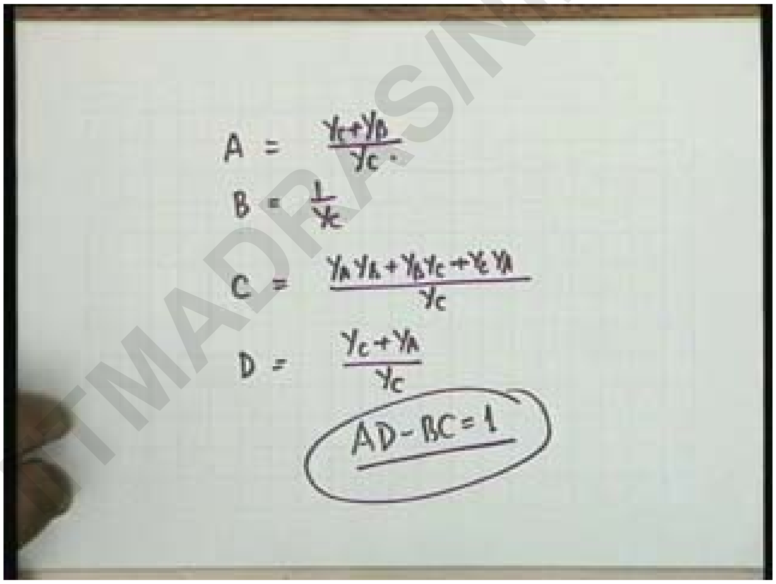

A B C D D is equal to YC plus YA divided by YC [Noise] B is equal to one over YC then C is equal to YA YB plus YB YC plus YC YA divided by YC and A is equal to YC plus YB divided by YC

and you can see that AD oh i am sorry yeah AD minus BC is equal to one AD minus BC yeah it's exactly equal to one

<a_side> yes sir <a_side>

[Noise] it has to be there is no other way suppose in a problem with a reciprocal network three of the parameters are given you can find the fourth agreed because you have this relationship AD minus BC is equal to one all right [Noise] we next go to the relationships between the parameters

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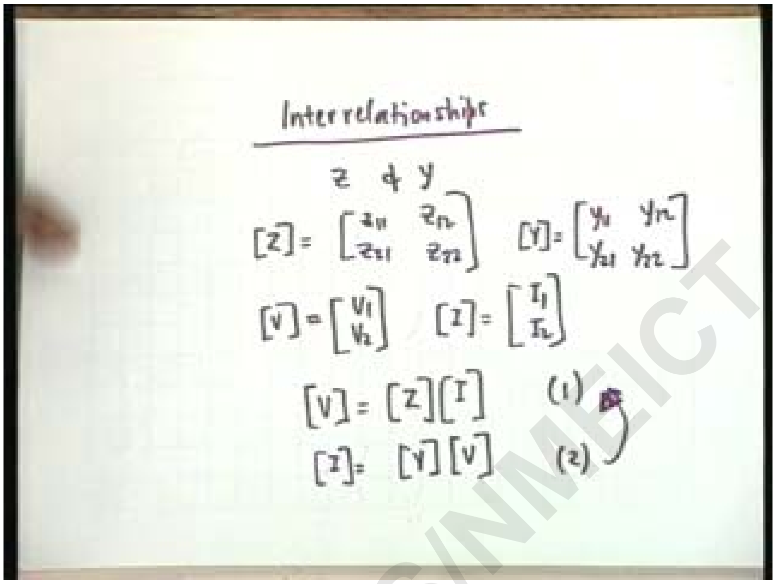

interrelationships the most commonly used parameters are z and y and therefore we start with z and y and we write this matrix Z matrix as z one one [Noise] z one two z two one and z two two and the Y matrix as y one one y one two y two one yt two two

the defining relations are [Noise] that the voltage vector V one V two

yeah pardon me

would you please say loud [Laughter]

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okay sure all right

the V matrix which is V one V two and the I matrix is I one I two these are vectors this is a column vector this is a column vector [Noise] and if you recall the defining relation is that V equal to Z I okay

the two equations that we wrote can be expressed in this form V one equal to z one one I one plus z one two I two and V two is equals to z two one I one plus V two two I two the other equation is that I equals to Y matrix multiplied by the V vector all right if i substitute equation two in equitation one two in one okay what do i get [Noise]

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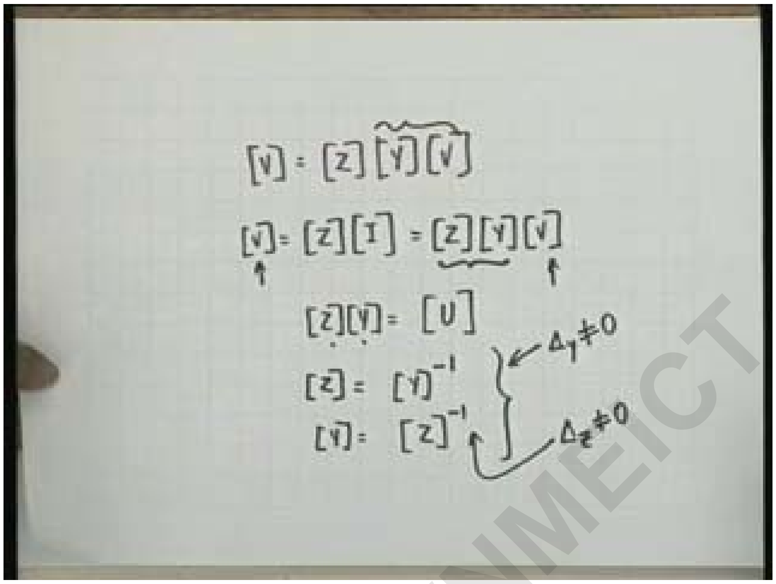

i get V equal to z instead of I i write YV okay this [Noise] is this clear how i wrote this would i repeat okay

what i have is V equal to Z I okay and I is Y matrix multiplied by V that's what i wrote here and therefore this matrix is the same as this matrix the pre-multiplying matrix must be an identity matrix

therefore Z Y [Noise] must be the identity matrix U of dimension two by two this is two by two this is two by two so multiplication of two by two by two by two which gives two by two what is the definition of the identity matrix

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diagonal elements are one off diagonals are zero okay and similarly Y matrix must be the inverse of the Z matrix this is the interrelationships between Z and Y matrices provided the inverse exists and the condition for that is that del Y the determinant of the Y matrix must not be equal to zero and the condition for this is that the determinant of the z matrix must not be equal to zero okay

and if i look at if i look at the expanded version of this inverse relationships

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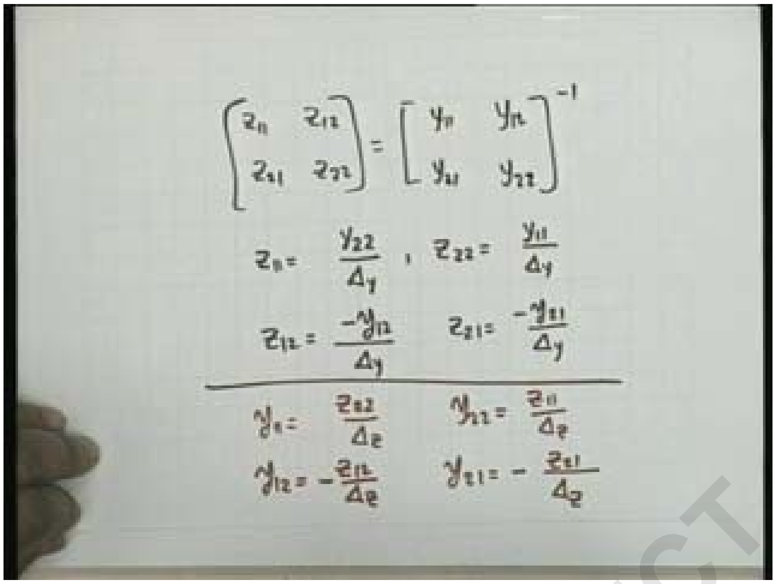

that is z one one z one two z two one z two two is equal to the inverse of y matrix if i look at this it's a two by two matrix very simple i can write down the relationships immediately z one one shall be equal to y two two divided by del y z two two shall be equal to y one one divided by del y

z one two shall be equal to

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minus y two one or one two one two there is a transposition one two by del y one must remember this one two

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now it is not two one there is a transposition after taking del one two by del there is a transposition and z two one is equal to minus y two one divided by del y

we are lucky that [Laughter] this do not interchange it's easy to remember okay all right

in a similar manner if you look at the inverse relationship obviously you can write [Noise] y one one is equal to s z two two by del z y two two is equal z one one by del z y one two is equal to z one two by del z not quite

<a_side> minus sign <a_side>

minus sign and Y two one is equal minus z two one divided by del C where del stands for the determinant of the particular matrix for example del y is equal to y one one y two two {multi} (00:22:05) minus y one two y two one okay now what we have said about [Noise] conversion of z to y or y to z the other two matrices that is the h and the ABCD obviously they don't obey inverse relationships because the variables are different the independent set of parameters is different so one has to work out from ABCD from the from no what is it called ab initio ab initio

ab initio means going back to the roots for example i will take only one example suppose i want to convert

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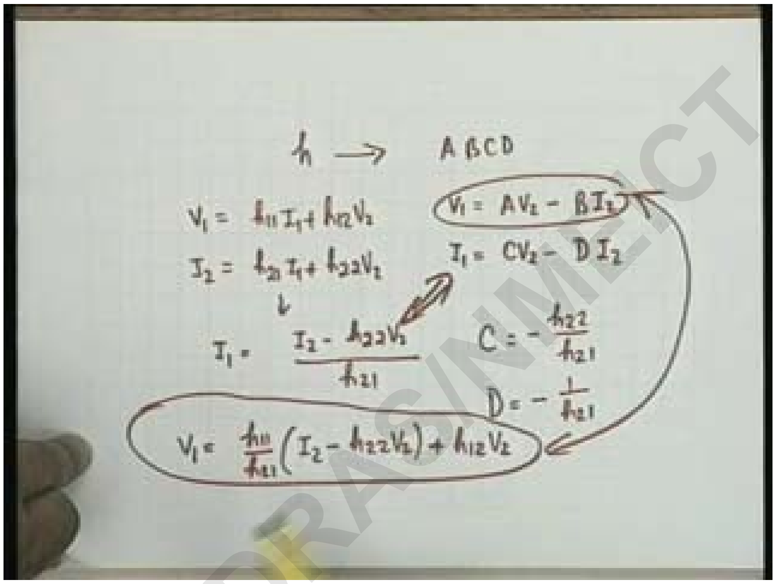

the h parameters to the ABCD parameters suppose i want to convert this then what i do is i write both the relationship that is i write V one h parameter relates V one I two to V one I two to I one V two

so h one one I one plus h one two V two and I two equal to h two one I one [Noise] plus h two two V two and i also write the ABCD parameters V one I one at the dependent variables and this is AV two minus BI two one must remember this and I one equal to CV two minus D I two all right

so what we have to do is express V one in terms of V two and I two in other words i have to eliminate I one from here and this is easily found from here I one is I two minus h two two V two divided by h two one which incidentally also gives me C and D if you compare these two don't you see that I one has been expressed in terms of I two and V two

so what is C

<a_side> minus h two two <a_side>

minus h two two divided by h two one and what is D

<a_side> minus one by h one one <a_side>

there is a minus sign because there is a minus sign here all right okay

now if i substitute this if i substitute this relation in the first one then i get V one equals to h one one by h two one I two minus h two two V two okay this is the first term h one one I one plus h one two V two

and if i look at this relationship and this one if i compare these two then i get the following equations for A and B

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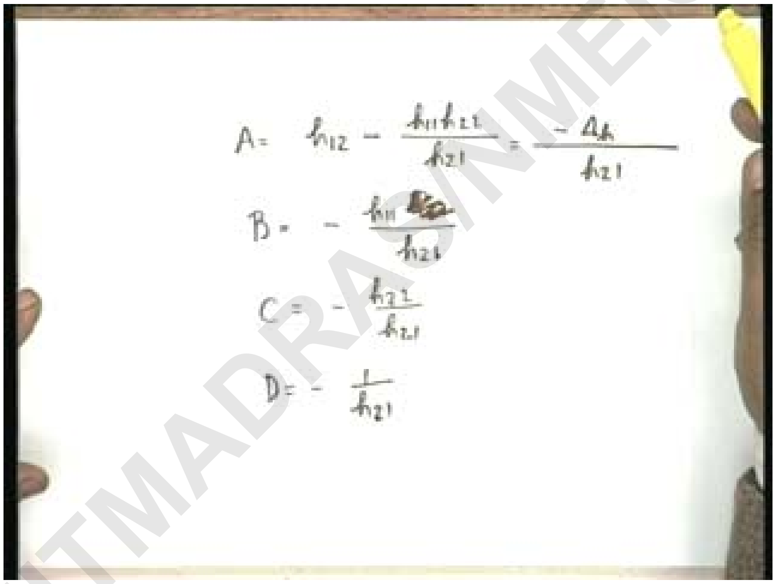

A is the coefficient of V two that is a that would be h one two minus h one one h two two divided by h two one okay and B B would be equal to minus h one one h two two divided by h two one

is it a minus sign

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you don’t have h two two this is a redundant term

is there a minus sign

<a_side> yes there is <a_side>

there is okay now let me write C and D also C was ah minus h two two by h two one and D was minus one over h two one okay

it appears that only this term does not come with a minus sign but if you if you simplify this the denominator is minus del h divided by h two one agreed

there is a uniformity all come with a negative sign all of them have a denominator of h two one h two one h two one h two one h two one

the three parameters BCD have a single term in the numerator h one one h two two one whereas A has the total determinant of the h matrix okay

in a similar manner we could go back from ABCD to h or z parameters to h parameters or y parameter to ABCD parameters all them can be done and this exercise at least for some parameters you should perform

this is the table that we get ultimately

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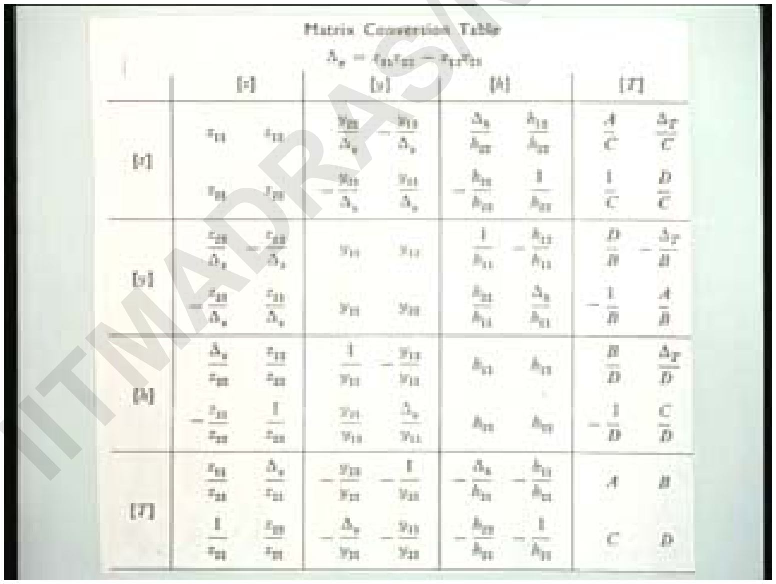

Matrix Conversion Table

$\Delta_z = z_{11}z_{22} - z_{12}z_{21}$

	[z]		[y]		[h]		[T]	
[z]	z_{11}	z_{12}	$\frac{y_{22}}{\Delta_y}$	$-\frac{y_{12}}{\Delta_y}$	$\frac{\Delta_h}{h_{22}}$	$\frac{h_{12}}{h_{22}}$	$\frac{A}{C}$	$\frac{\Delta_T}{C}$
	z_{21}	z_{22}	$-\frac{y_{21}}{\Delta_y}$	$\frac{y_{11}}{\Delta_y}$	$-\frac{h_{21}}{h_{22}}$	$\frac{1}{h_{22}}$	$\frac{1}{C}$	$\frac{D}{C}$
[y]	$\frac{z_{22}}{\Delta_z}$	$-\frac{z_{12}}{\Delta_z}$	y_{11}	y_{12}	$\frac{1}{h_{11}}$	$-\frac{h_{12}}{h_{11}}$	$\frac{D}{B}$	$-\frac{\Delta_T}{B}$
	$-\frac{z_{21}}{\Delta_z}$	$\frac{z_{11}}{\Delta_z}$	y_{21}	y_{22}	$\frac{h_{21}}{h_{11}}$	$\frac{\Delta_h}{h_{11}}$	$-\frac{1}{B}$	$\frac{A}{B}$
[h]	$\frac{\Delta_z}{z_{22}}$	$\frac{z_{12}}{z_{22}}$	$\frac{1}{y_{11}}$	$-\frac{y_{12}}{y_{11}}$	h_{11}	h_{12}	$\frac{B}{D}$	$\frac{\Delta_T}{D}$
	$-\frac{z_{21}}{z_{22}}$	$\frac{1}{z_{22}}$	$\frac{y_{21}}{y_{11}}$	$\frac{\Delta_y}{y_{11}}$	h_{21}	h_{22}	$-\frac{1}{D}$	$\frac{C}{D}$
[T]	$\frac{z_{11}}{z_{21}}$	$\frac{\Delta_z}{z_{21}}$	$-\frac{y_{22}}{y_{21}}$	$-\frac{1}{y_{21}}$	$-\frac{\Delta_h}{h_{21}}$	$-\frac{h_{11}}{h_{21}}$	A	B
	$\frac{1}{z_{21}}$	$\frac{z_{22}}{z_{21}}$	$-\frac{\Delta_y}{y_{21}}$	$-\frac{y_{11}}{y_{21}}$	$-\frac{h_{22}}{h_{21}}$	$-\frac{1}{h_{21}}$	C	D

this is the complete table where it does not assume that the network is reciprocal it is a general table and you should keep a copy of this ready with you in working out problems on problems in network theory because you never know where you shall require a conversion this incorporates T to pi and pi to T T to pi means z parameters to y parameters and pi to T is y to z parameters

you see for example the table is read like this the z matrix and the z matrix so this is this gives the matrix z matrix is this visible on the monitor

<a_side> no <a_side>

okay no what is the problem oh okay you tell me to the shift is that okay now okay

z parameters z and z that is the one one is simply matrix {is} (00:28:10)

if you go from z if you wish to derive z from y okay the row is all z parameters and the column is in terms of those parameters if you want to find z from y parameters then you use this relation that is z one one is y two two by del y z one two is minus y one two by del y as we have done already

or let's say you want to find out z parameters from ABCD parameters then z one z one one you A by C all right z one two is del t by C del t is simply AD minus BC which is equal to one for reciprocal network this is a general table and therefore they have used del t

similarly z two one is one by C and z two two is D by C and similarly for all other entries in the table this is a [Noise] very important table and very useful table and I would advise that you keep it ready for reference all right

any question

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from the book yeah course book any network theory any respectable network theory book would have this table okay any respectable network theory book but be aware ah some of the books particularly the Indian authors have many miss prints and uh it is better that you take from course book all right [Noise]

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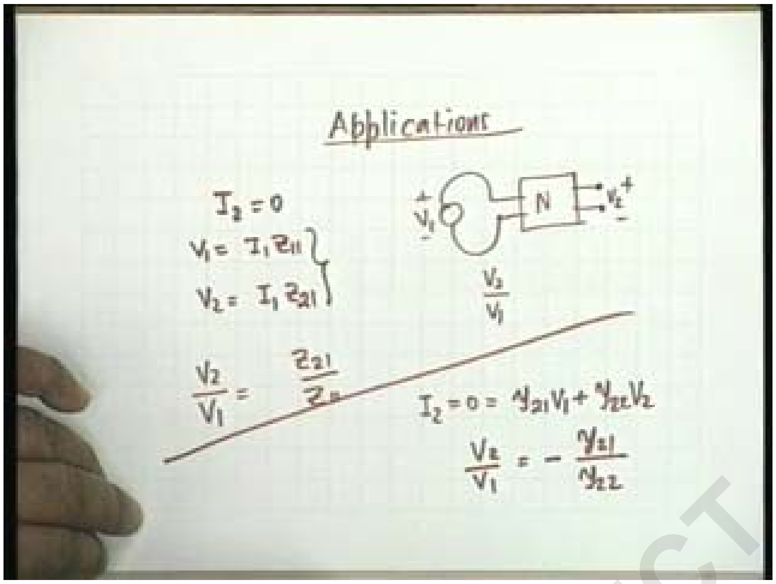

we then have a brief discussion on applications of the two port parameters application of the two port parameters in finding out network functions network functions are driving point and transfer could be impedance could be admittance or in the case of transfer it could be dimensionless

now given a network given a network N and its two port parameters any transfer function can be found out any transfer function and we shall have a graduated series of examples to illustrate the applications

the first one that i have is suppose i connect the voltage source here V one and i want to find out the voltage output voltage V two that is my transfer function is V two by V one all right

the parameters you can use any set of parameters but the condition is that I two equals to zero if I two equals to zero then you know that V one would be equal to i one z one one if i work in terms of the z parameters and V two shall be equal to I one times z two one that is correct because I two equal to zero therefore my V two by V one is simply z two one by z one one

can i explain you see my condition is this is kept open and therefore I two is zero

< a _ side > is it the implied condition < a _ side >

not implied condition there is a given condition given conditions if i connect something here then obviously I two shall not be equal to this but what i want is opens circuit voltage transfer function

if I two is zero then my z parameters give these two relations and therefore i find V two by V one suppose one is per say i don’t know the z parameter i know the y parameter and i don’t want to convert fine fine

what i will do is i will write the equation for I two I two is equal to zero equal to y two one V one plus y two two V two and therefore V two by V one is equal to minus y two one divided by y two two all right is that okay

i can find out in terms of z parameters or y parameter and since i know the relationship between z and any other set of parameters what i will require is only to look at the table to be able to convert this for example in terms of A B C D parameters

all that i do is substitute for z two one in terms of A B C D substitute for z one one in terms of A B C D or else i go back to the roots that is i write the defining equations put I two equal to zero and then what ever V two by V one comes i accept it

is this okay all right this is the first example the simplest one

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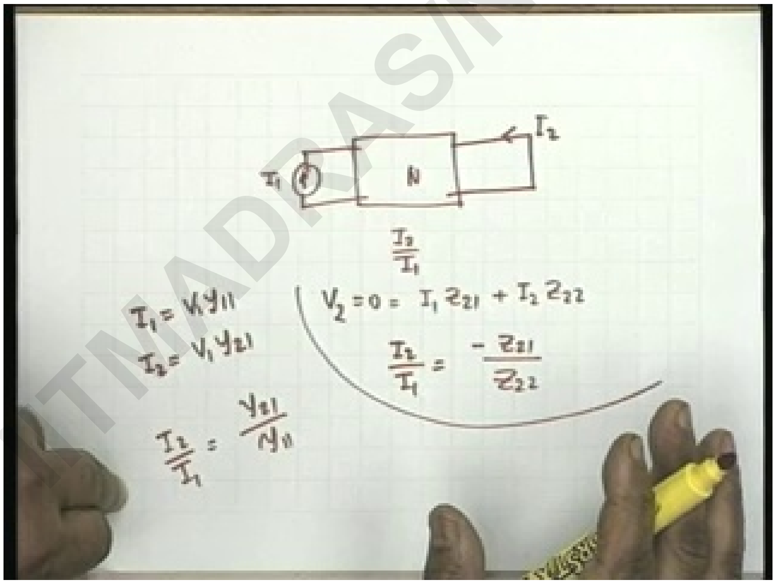

the second example well it's also very simple i have this well situation in which the network N is driven by current generator I one the output is short circuited I two and what i want to find out is I two by I one this is my transfer function okay

if i take z parameters let’s say then in the second equation V two is equal to zero is equal to I one z two one plus I two z two two and therefore I two by I one would be equal to minus z two one divided by z two two agreed as simple is that from the second equation or if i want in terms of the y parameters what i will do is i take the two equations I one shall be V one Y one one because V two is zero and I two is V one y two one all right therefore I two by I one is equal to y two one divided by y one no negative sign okay

similarly i can find out from any other set of parameters i will confine my attention to z and y other parameters you can try for your self

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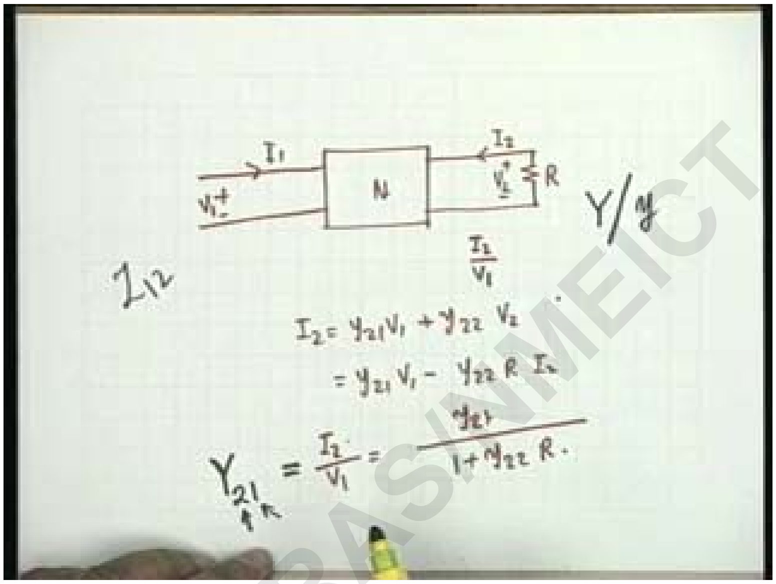

the third example that i take is slightly more involved that is a terminated network i have a network N i can connect either source here but all that matters is V one and I one and i terminate this by means of resistance let's say R the function of interest is I two by V one okay if capital R was replaced by a voltage source V two then what would have I two by V one become

yeah

< a _ side > (( )) (00:35:33) < a _ side >

ah [Noise] what would you like me to try z parameters or y parameters let’s find this out then we will will will conclude let’s use y parameters

are they easy to use well either of them is easy there is no problem why do i use y parameters

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minus V two by R that's perfectly all right that is what we shall use you see I two is y two one V one i want I two by V one I two is y two one V one plus y two two V two but what is V two

< a _ side > minus I two R < a _ side >

so it is minus y two two R I two therefore I two by V one is equal to i can write it down y two one divided by one plus y two two R all right

now i {waa} (00:36:40) i want to ask you the following question if capital R is zero that is if this is short circuit then what is I two by V one it is simply small I two one that is the definition okay

so a [Noise] now i am introducing a notation you must be careful about this notation when i write a small y it refers to a transfer admittance of the network all right

now I two by V one is also a transfer admittance I two is the current in the load and V one is the voltage at port one so I two by V one is also a transfer admittance how do you distinguish between the two use a capital Y and use the subscripts two one

capital Y two one now you must be able to distinguish between capital Y and small y okay make them quite different don’t make them look alike because then you might make a mistake

< a _ side > (( )) (00:37:44) < a _ side >

why you use this okay you see if capital R is zero if this is short circuited then I two by V one is simply {mi}(00:37:55) small y two one which means the parameter of the network N it has nothing to do with terminations okay

the parameter small y is defined without termination now with termination I two by V one is still the dimension of an admittance and it is a current at one port to the voltage at the other port so it is a transfer admittance all right

small y two one we call it short circuit transfer admittance that is it it belongs to the network N whereas under terminated condition to distinguish between small y two one the short circuit transfer admittance and the transfer admittance of a terminated network we use the symbol capital Y

the subscripts are still two one two the first subscript refers to the port at which the response is taken okay that is at port two and the second subscript refers to the port at which the excitation is applied this this will be our convention

y two one shall be that we are interested in a current at port two due to a voltage at port one similarly if i had written z one two this will mean that we are interested in a voltage at port one due to

< a _ side > current at port two< a _ side >

a current at port two is that okay this will be our convention all right and in the context things will be absolutely clear

now suppose suppose you are fussy and you say no i don’t want to work with y parameters i want to work with z parameters well all that i have to do is to refer to the table the place y two one by by what

< a _ side > z parameter < a _ side >

what is the z [Laughter] parameter

< a _ side > z one two by del z < a _ side >

plus or minus

< a _ side > sir minus < a _ side >

minus z one two by del z and y two two i shall replace it by z one one by del z and work it out or i can go back to the rules okay i can do that

let's take the next example before taking the next example let me point out one ah [Noise] one of the interesting ah equivalent circuits you see i told you that as per as z parameter is concerned

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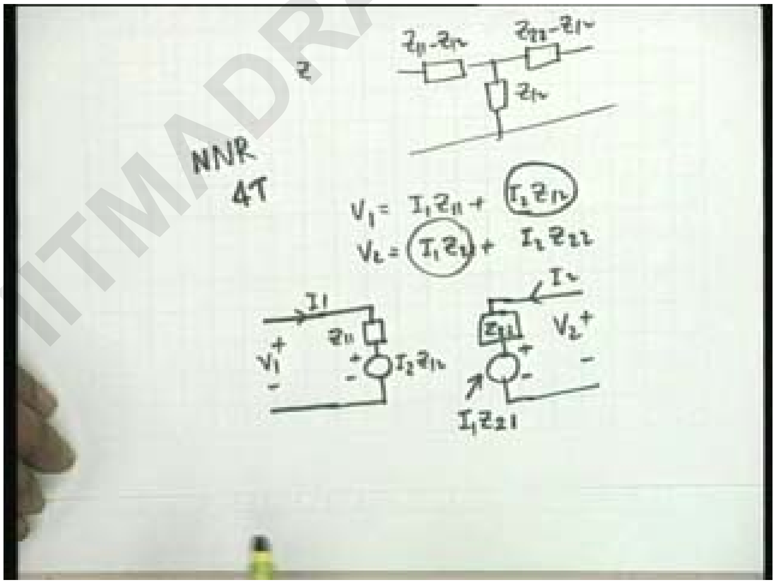

if the network is reciprocal and three terminal then you can replace the network by a T network like this where these parameters are z one one minus z one two z two two minus z one two and z one two if the original network is reciprocal but not three terminal then this represents only a mathematical equivalent circuit all right not a physical one on the other hand if the network is reciprocal reciprocity is a must

if the network is reciprocal and the three terminal this represents the physical equivalent circuit also [Noise] suppose it's neither

suppose the network is not necessarily reciprocal not necessarily reciprocal that means it can be nonreciprocal also and it is truly four terminal can you draw an equivalent circuit well this is simplicity itself the drawing of the equivalent circuit

if i write I one z one one plus I two z one two and V two equal to I one z two one plus I two z two two then it's common sense that this equivalent circuit describes the network

that is you have a z one one a current I one V one so V one equal to I one z one one plus a quantity I two z one two which is the dimension of voltage so i connect a voltage generator here which is I two z one two obviously is that okay it's very simple V one equal to I one z one one plus this voltage source

now obviously this is not an independent voltage source it is a controlled source it is a dependent source the source depends on the current at port number two which is I two okay this current determines this voltage so it is a controlled source and by a similar by a similar argument the equivalent circuit at port number two is that we shall have a z two two here and another voltage source which would be plus minus and the value would be I one z two one okay this is the term that we have to use

< a _ side > (( )) (00:43:09) < a _ side >

small c

< a _ side > intrinsic < a _ side >

yes the network parameter no termination now is this is this clear

this is a truly four terminal truly four terminal and it does that assume either reciprocity or non reciprocity we have used z two one and z one two we have not assumed them to be equal and therefore this is a general equivalent circuit

what have we achieved through this equivalent circuit nothing much we have simply represented instead of equations we have represented this by means of a circuit the circuit contains two controlled sources the two circuits although shown physically isolated from each other are not really isolated why because the coupling coupling comes to the control sources you see this current control space so the two circuits are not decoupled from itself

although physically there is no connection but there is a connection through the control of a voltage source by a current source similarly control of this source by the current source

so {it }(00:44:24) we have not achieved much we have simply represented the equations by means of an equivalent circuit however sometimes this equivalent circuit is of great help great simplification as we shall show in one or two examples but by a similar token you can represent the y parameters

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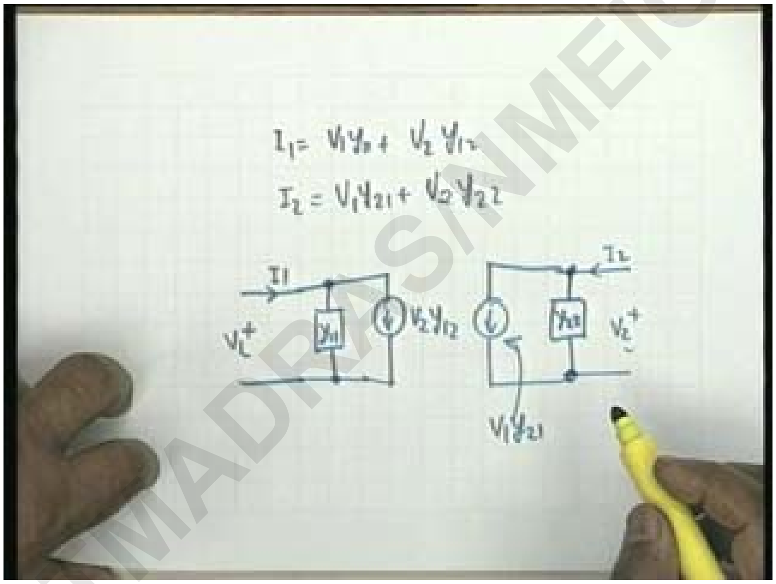

I one equal to V one y one one plus V two y one two and I two equal to V one y two one plus V two y two two you can represent this by a dual circuit that is what you do is V one I one I one is V one times y one one

so introduce an admittance y one one here okay plus another current and this current would be V two y one two it is a current source controlled by the voltage at port two okay it’s a current source controlled by voltage at port two V two

in a similar manner for the other port V two and I two I two is V two y two two so we have an admittance y two two here and another current source controlled current source whose value would be V one y two one all right this is an exact dual of the z parameter equivalent circuit in the case of z parameter there was a series connection of a voltage source and an impedance now you have a parallel connection of an admittance and a current source okay

as i said you have not achieved much you have only represented two equations by means of a circuit but a circuit a picture is a word one thousand words as we shall see in in a few examples okay

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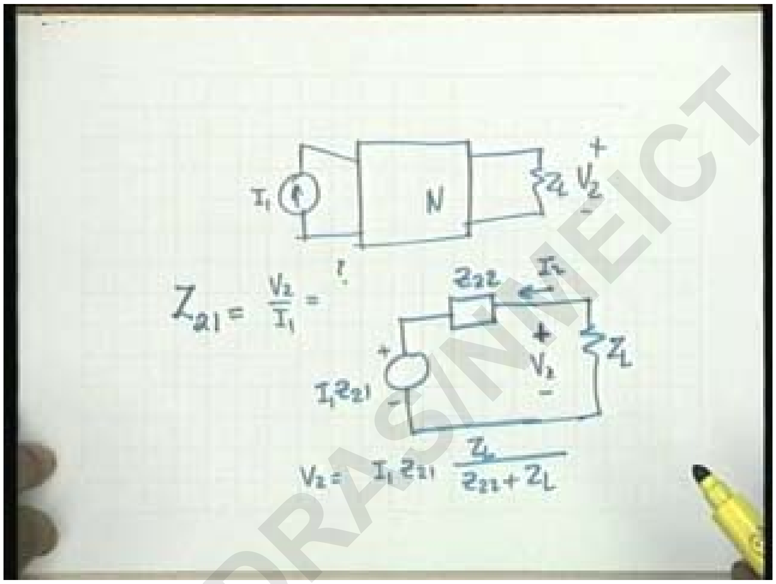

suppose we have a current source one example of application of this suppose we have a current source and network and and the termination z L the output voltage is V two and what we want is V two by I one what is it a transfer impedance okay and we should represent it by capital Z

< a _ side > two one< a _ side >

two one that is correct capital Z two one this is what you want

now instead of going into any other any other part if we simply represent if we simply take the z parameter equivalent circuit what was the output equivalent circuit you have a V two V two you have a series impedance z two two two this is the current I two and a voltage source

what is the value

< a _ side > I one z two one < a _ side >

I one z two one agreed and what we have done here i don't have to draw the other part because i don't need it what i need is a relation between V two and I one I one is already here okay so what i have here is a an impedance let's say z L and what i have to find out is the ratio V two by I one obviously V two is equal to I one z two one times z L divided by z two two plus z L is it okay simply a potential division this is the voltage source and there is a potential division between z two two and z L all right and therefore in one stroke of the pen we find out

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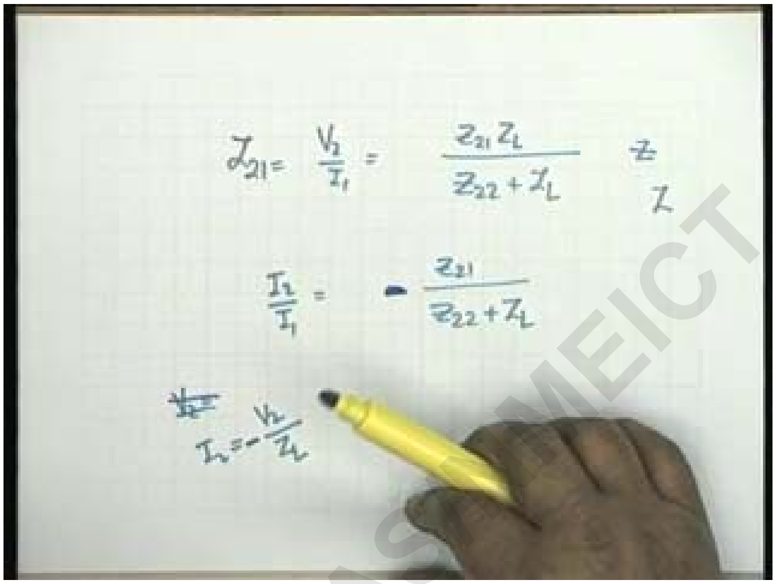

the transfer impedance z two one as V two by I one as equal to z two one z L divided by z two two

distinguish between small and capital i always cross the middle draw a horizontal line in the middle to indicate small z and don't do it for capital Z okay this is how i i differentiate

suppose ah suppose in this example it is not V two well suppose the quantity of interest is I two that is the current current show this impedance I two

can i find out the transfer function I two by I one very simply I two is related to V two

< a _ side > (( )) (00:49:28) < a _ side>

no i don't need that V two is equal to well I two is equal to V two divided by z L with a negative sign agreed so all that i have to do is yeah what did you say

<a _ side > sir z one z two one plus z two two by to z L < a _ side >

there is a mistake

< a _ side > (( )) (00:49:58) < a _ side >

there is a minus sign all i have to do is to divide this transfer function by minus one by z L all right so z L z L cancels the negative sign this you must not forget all right

the last example

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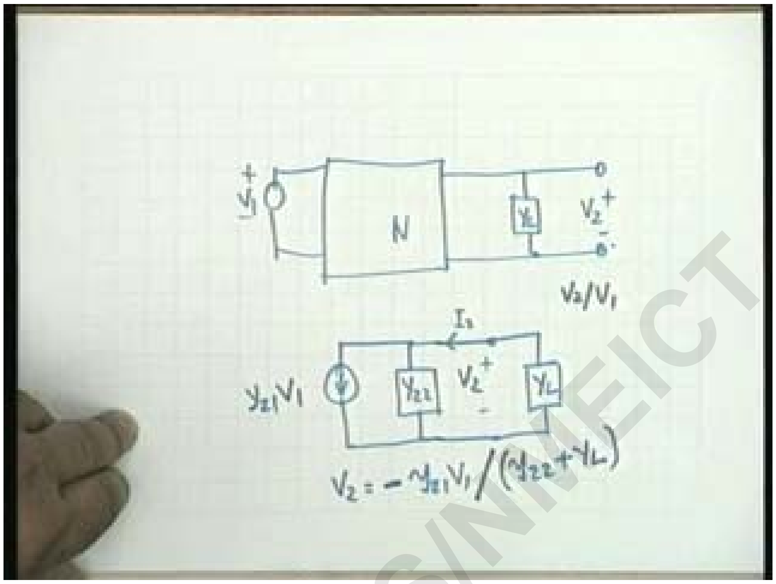

we have a voltage source V one the network N and an admittance y L our quantity of interest is V two and i what i want to find out is V two by V one

now in this situation also the y parameter equivalent circuit the four terminal comes into help if you recall from the load end from port number two what i have is an admittance y two two and a current source

how much y two one times

<a_side> I one V one <a_side>

V one so i don't have to draw the other part at all all i do is connect a y L here okay

so ah V two is obviously equal to V two is the drop due to a current y two one V one flowing into a parallel combination of y two two and y L agreed

this is a current source which flows to this parallel combination to produce a drop of V two so V two is Y two one V one current multiplied by impedance yeah there is a minus sign here minus sign because V two and y two and V one they don't agree

therefore minus y two and V one divided by y two two plus YL agreed

let me write it down again

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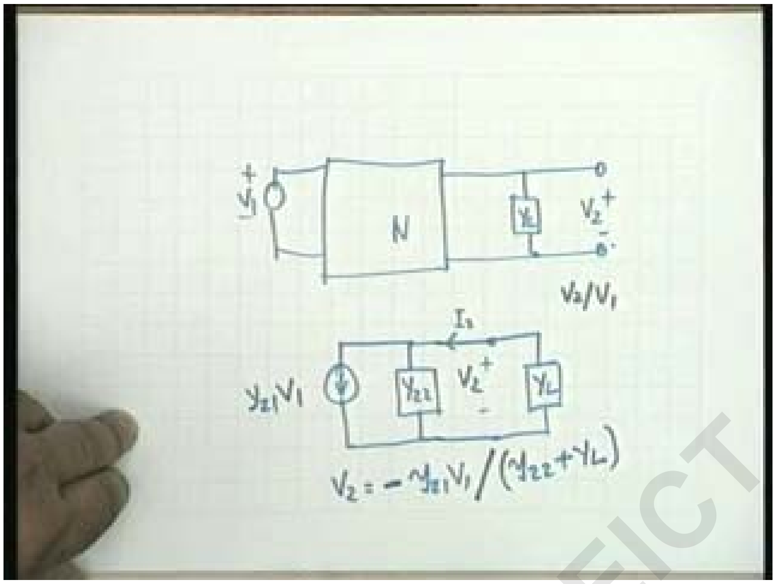

V two by V one is equal to minus y two one divided by y two two plus YL and what was the situation N there is a V one here and there is a YL here this is V two

now i want to recall i want you to recall that if YL was equal to zero if YL was equal to zero which means that the termination is open circuit

then the transfer function open circuit voltage transfer function was precisely this was derived earlier minus y two one by y two two which checks all right it checks

the the question that i leave you is that is there a preferred method of solution

given a problem is there a prepared method which parameters to use which equivalent circuit to use and so on is there a preferred method

my answer is no and yes [Laughter] what does it mean

there is a preferred method which comes there is no prescription

you can't say if this this this are to be found out and this this are given you follow z parameter no there is no prescription it comes by experience

that means you solve more and more problem then given a problem it will be obvious to you which parameter should we use all right

next occasion we shall take more examples and then go about to interrelations