Basic Electrical Circuits
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Lecture - 80
Y Parameters

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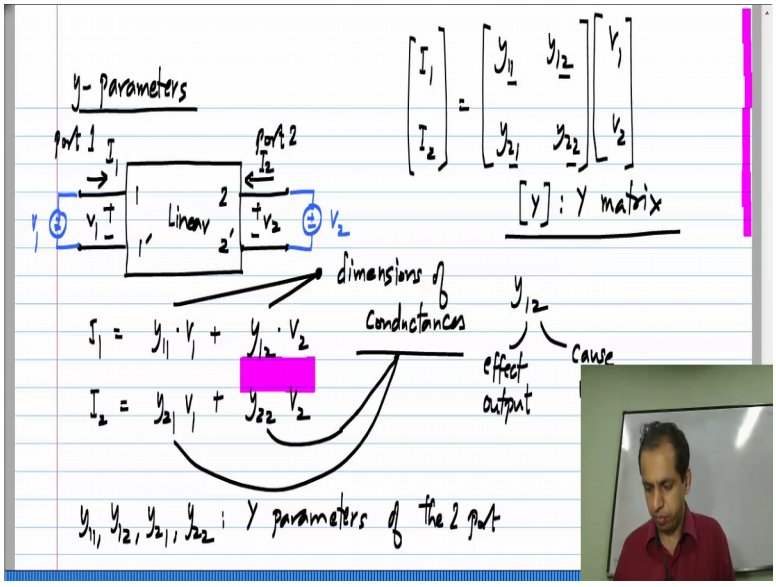

In this lesson, we will consider y parameters which correspond to one particular choice of dependent and independent variables. Let us consider a linear network again this means that there are no independents sources inside,, but there can be dependent sources and linear resistors this is port one this is port two and let think of voltages being applied to these ports V 1 applied this way V 2 apply that way and. So, we will have V 1 across this and V 2 across this and we have I 1 here and I 2 there again these directions are convention for defining the variables actual current may be anything depending on the in sets of the circuit. Now as we know because these is the linear circuit every branch voltage and current inside will be a linear combination of the independent sources applied which are V 1 and V 2.

So, I 1 and I 2 will also linear combinations of V 1 and V 2. So, I 1 will be something times V 1 plus something else time V 2 clearly to have dimensions consistency these quantities here must have dimensions of conductance. In fact, this is the reason it is called y parameters we know that G is the letter used to denote conductance, but for frequency dependent circuit is there is generalized form of conductance known as admittance which is also the ratio current to voltage and that happens to be denoted by

letter y. So, these parameters which have these conductance as the proportionality constant in the linear combination are called y parameters, for now just a name for us these are called by parameters and these y parameters have dimensions of conductance. And similarly the current I 2 will be a linear combination of V 1 and V 2 and these constants again have dimensions of conductance.

Now, these four parameters together y 1 1 y 1 2 y 2 1 y 2 2 these are the y parameters of the two port now this relationship can also be expressed more compactly if you write two currents as a letter of length two and we have y 1 1 y 1 2 y 2 1 y 2 2 arranged as a matrix times vector of voltages V 1 V 2. So, I 1 is y 1 1 times V 1 plus y 1 2 times V 2 I 2 is y 2 1 time V 1 plus y 2 2 times V 2. So, this matrix here is many times called the y matrix of the two port network. So, the y matrix consist of four parameters because we have two dependent variable and two independent variables there are four parameters relating the currents to voltages and these sub scripts here. So, let us take y 1 2, so the first sub script denotes the effect meaning I 1 I 1 is y 1 2 times V 2. So, what is y 1 2 times V 2, it is contribution of V 2 to I 1, so I 1 is a effect V 2 is the cause.

So, the first sub script denotes which effects and second one denotes which the causes or in other words you can think of this is the input and this is the output. So, V 2 gets scale by y 1 2 to give you I 1. So, that is the meaning of the subscript and you can see that for the rest of them it is same way V 2 gets scale by y 2 2 to give you I 2 and so on so that is the definition of the y parameters. So, far we have not done anything special. So, we knew that I 1 and I 2 would be linear combinations of V 1 and V 2 and that is what we have expressed and there is standard way of putting down these things and that is what I have shown here.

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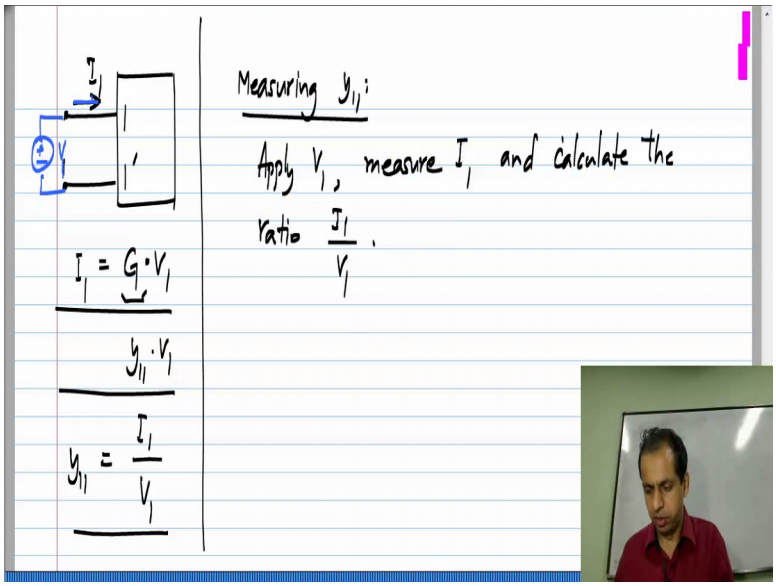

Just make an analogy with one port, if you have a single port and you have think of V as the cause let say V 1 there is a only one port. So, V 1 as the cause and I 1 as the effect, we know that I 1 is some conductance times V 1 what we have is exactly the same. We calls this something else, we call it y 1 1 times V 1; in case of a one port circuit or one port network, we have only one parameter in case of two port network we have four parameters. And similarly you can imagine that in case with three port network, we will have nine parameters, because we will have three voltages and three currents and so on. So, if you have n port network, you will have a parameters relationship between N voltages and N currents.

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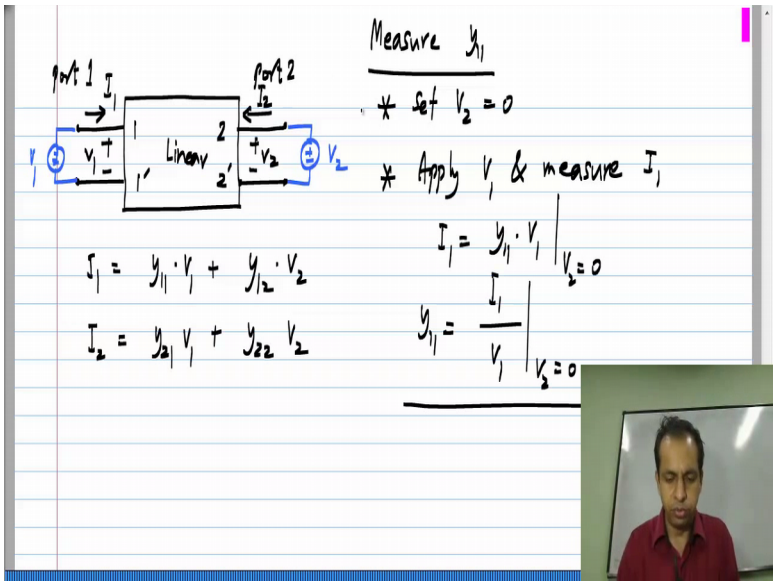

Now, let us consider this once again we also need to figure out how to the measure this parameters meaning in this case, when we have a one port, we know how to measure it, we apply the volts and find the current and ratio of the current to voltage this is the single y parameter out there I can call this conductance as this parameter y 1 1, there is only one parameter in case of one port. So, how do you do this you apply V 1 measure I 1 and calculate the ratio I 1 by V 1. So, that is how we measure this parameter what do you do in case of two port we have four parameters. So, that is means that we need that four measurement and convenient way of doing it is let say we want to measure y 1 1 y 1 1 appears in this first equation the easiest way, it is to set V 2 to 0, so that is second terms disappears completely and we have I 1 equals y 1 1 times V 1 and from that we can measure y 1 1. Set V 2 to 0, apply V 1 and measure I 1, because we said V 2 to 0, I 1 will simply be y 1 1 times V 1 this is with V 2 equal to 0, so y 1 1 is noting but I 1 divided by V 1 when V 2 is set to 0.

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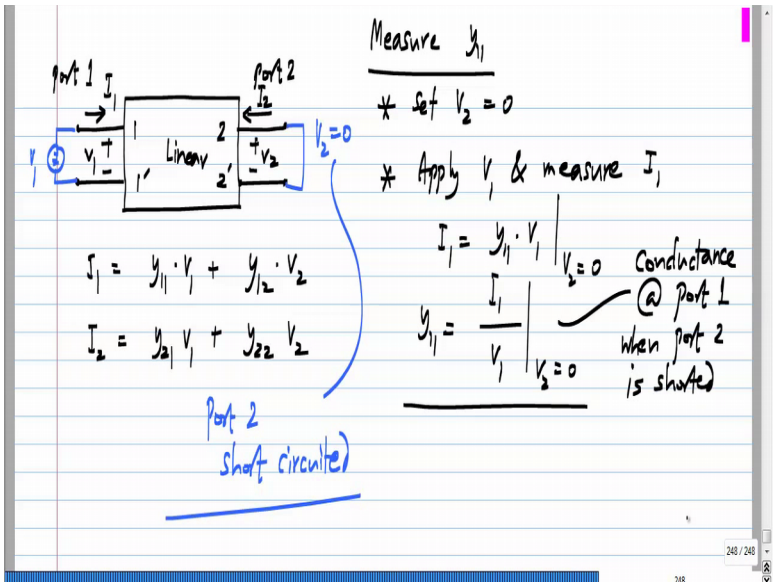

In other words, What is the meaning of setting V 2 to zero we short circuit the second port. So, you short the second port and essentially measure the conductance looking in to the first port, because when you short circuit the second port this whole thing. We just have these two terminals to play with we apply a voltage and find the current going there take the ratio of current voltage. So, this is nothing but conductance and port one when port two is short at so that have we measure y 1 1.

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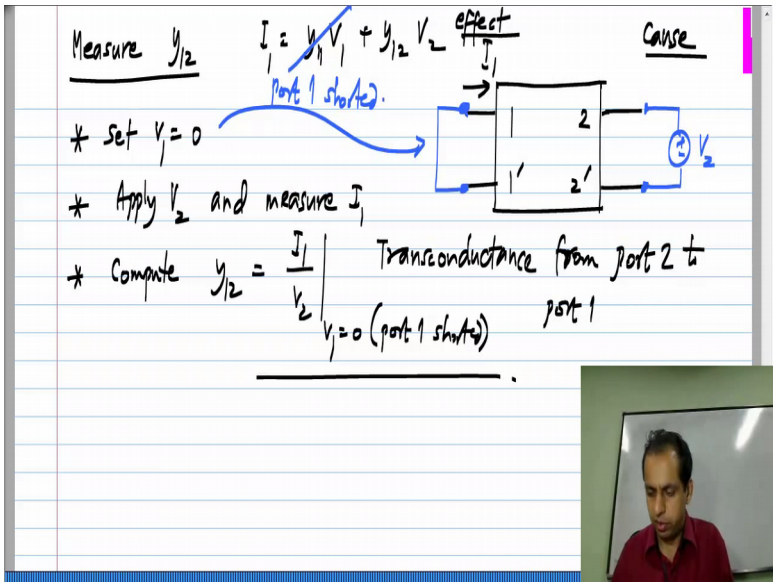

So, we can continue this for other three parameters if you want measure y 1 2 what you do you set V 1 two zero the idea is the same I 1 is y 1 1 V 1 plus y 1 2 V 2. So, if you set V 1 two zero this time disappears and you will have the only the term containing y 1 2 then you apply V 2 and measure I 1 meaning we have ports one and two this is V 2 we short circuit port one that is the meaning of setting V 1 to 0, and we apply V 2 and measure I 1 that is we measure the current in port one while applying the voltage two port two. And you can compute y 1 2 as I 1 by V 2 with V 1 set to 0, which means port one short at.

So, unlike in the case of conductance your measuring the current and port one there is voltages apply down port two such a measurement it is non trans conductance measurement that is you apply the voltage here and measure the current else where we apply the voltage at the port and the measure the current at the same port you will be measuring the conductance. If you apply about the some port measure the current at some other port you will be measuring the trans conductance. So, this can also be called trans conductance from port two to port one that is the cause the stimulus is on port two and the effect or the response is on port one now we can see that.

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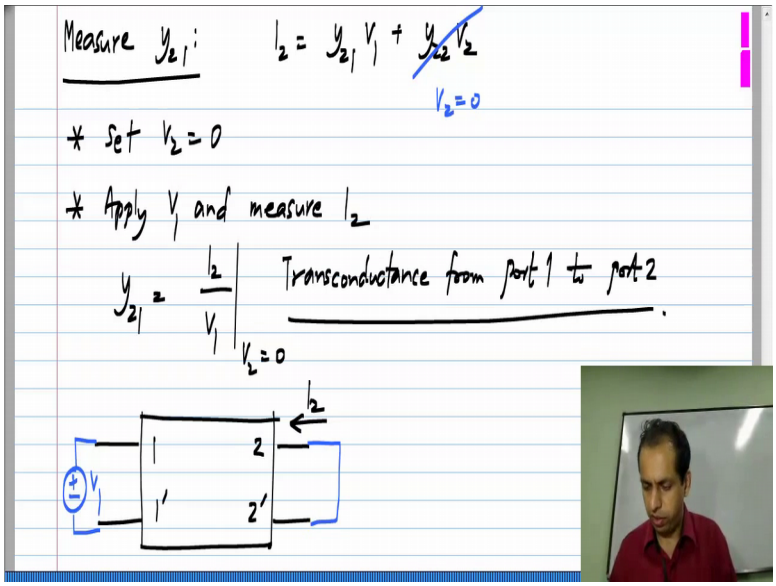

By obvious extension, we can measure the other two parameters as well you can measure y 2 1 I 2 is y 2 1 V 1 plus y 2 2 V 2 retain only the term containing y 2 1 we set V 2 to zero. So, set V 2 equal to zero apply V 1 and measure I 2 y 2 1 will be the ratio of I 2 by V 1 with V 2 being zero and if I draw the circuit for it I apply V 1 to the first port I short circuit the second port and I measure the current I 2. So, I measuring the trans conductance from port 1 2 port two with port two short circuited.

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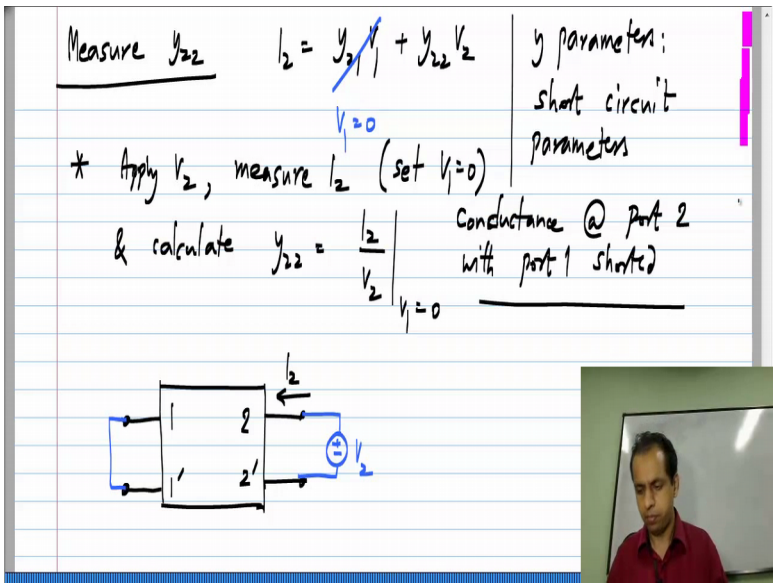

Finally, to measure y 2 2 I 2 is y 2 1 V 1 plus y 2 2 V 2 and to measure y 2 2 we said V 1 is equal to zero. So, that the terms of the way and a apply V 2 measure I 2 after setting V 1 to zero and calculate y 2 2 as the ratio of I 2 by V 2 with V 1 being zero and what is

this ratio y two by V 2 we short circuit port one and we apply V 2 here and I 2 goes in there. So, essentially we are measuring the conductance looking in to port two with port one short circuited. So, this is the conductance at port two with port one short it. So, this is how we would go about evaluating the four parameters. So, if you are given a circuit, and you will see in the worked out examples letter, what you have to do to measure this four parameters is to make four measurements the most convenient way do that is to short one of the ports, and make measurement on the two ports then short the other port and make measurements on the two ports so that will give you four parameters.

Now, to be sure the other ways of doing it is simply take for different combination V 1 and V 2 and measure currents I 1 and I 2 for these combination you will get four different equations and from that you can solve for the four parameters,, but these is the most convenient way of computing the four parameters. Now because the measurement of y parameters involves shorting of the ports y parameters are also known as short circuit parameters.

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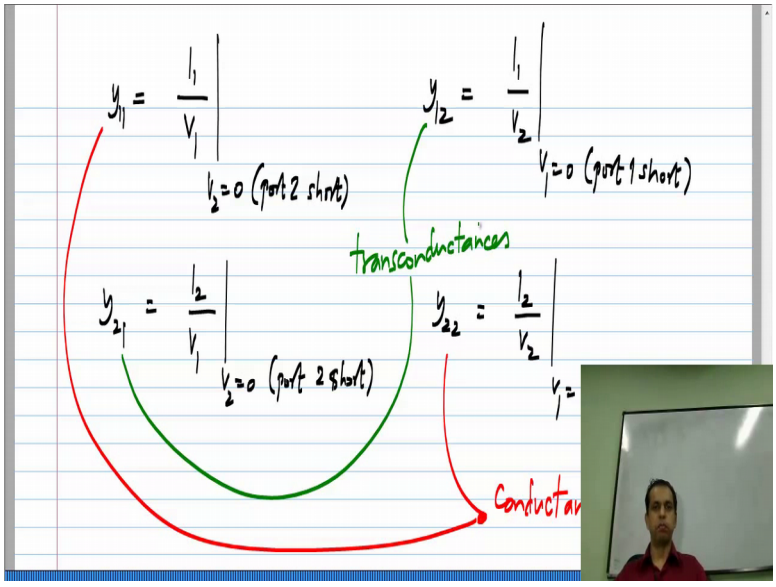

So, to summarize y 1 1 is I 1 by V 1, remember the second sub script goes here on the first one goes over there with V 2 equal to 0, meaning port two is short it and y 1 2 is I 1 by V 2 with V 1 equal to zero or port one short it y 2 1 is I 2 by V 1 with V 2 equal to zero, so that is port two short it. And finally, y 2 2 is I 2 by V 2 with V 1 equal to zero port one short it. So, what you can do is you short port two that is you said V 2 equal to 0 apply voltage V 1 then you can measure I 1 to get 1 1 I 2 to get y 2 1 then you remove the short from port two. And then short port one instead and apply V 2 to port two then

you measure I 1 to get y 1 2 and I 2 to get y 2 2. Now these two y 1 1 and y 2 2 are conductance of course under specific conditions it is the conductance looking in to the circuit with the other port short it and this y 2 1 and y 1 2 are trans conductance that is the ratio of current voltages, but not on the same port the current is set at some port and the voltages are some other port.