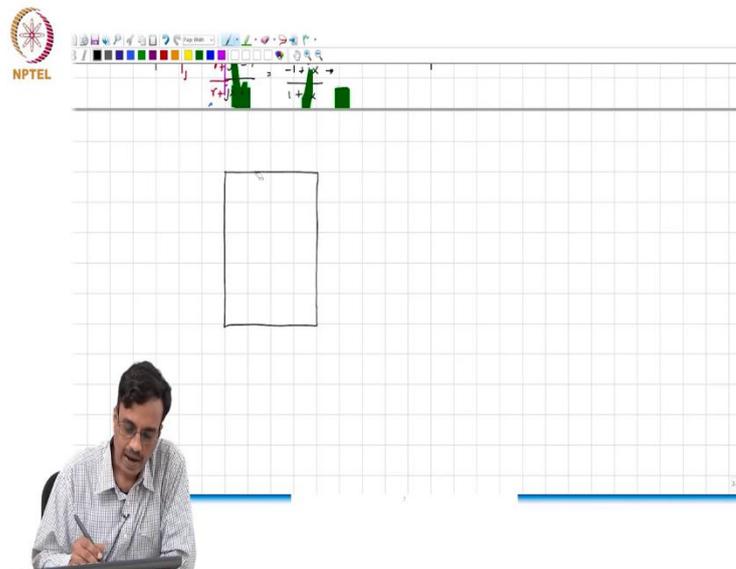


Circuit Analysis for Analog Designers
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Lecture - 48
The need for scattering parameters

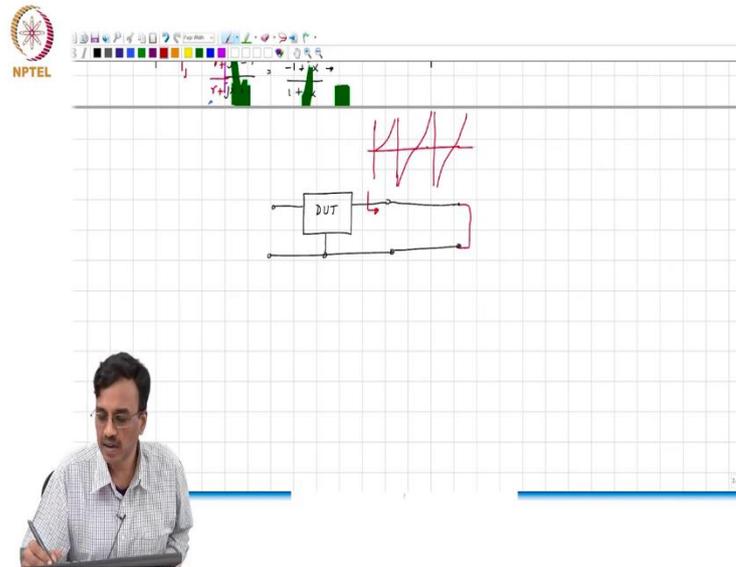
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The next thing I would like to talk about is representation of two ports or multiple I mean or multiport using the scattering parameters and the reason why they are important. As we have seen yesterday you know trying to measure either the impedance or the admittance parameters mean that you need to terminate an amplifier or whatever you are trying to measure with open or short circuits.

And as we have already seen you know the notion of perfect short does not exist ok because the length of the transmission line connecting the output port of the device under test ok.

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So, basically let us say you have is often called the DUT; Device Under Test. And for example, if you wanted to measure the admittance you would technically have a transmission line and then you would attempt to terminate this with a short circuit. But even though this is a short circuit as we have already seen at great length the impedance that the Device Under Test sees is not a short, it can go from anything, which is a short circuit to anything which is an open circuit.

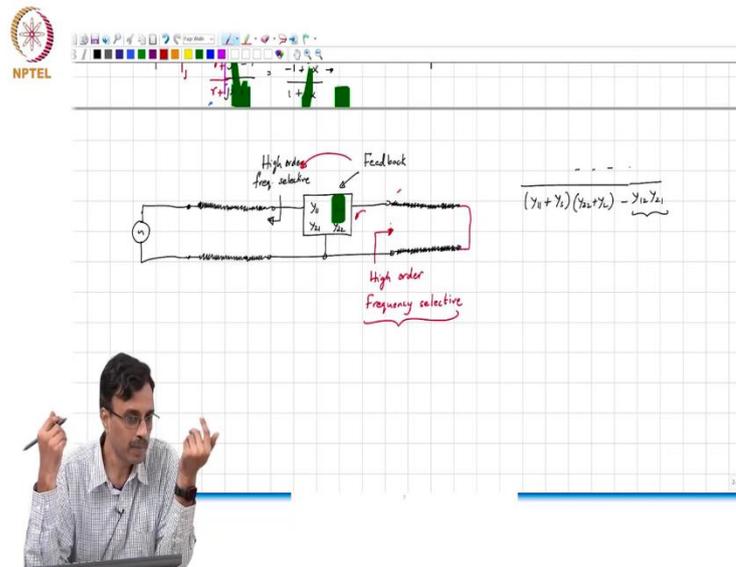
So, the impedance here as we have seen you know if I plot the magnitude of the reactants. It basically does not the magnitude if you plot the reactants, it basically does something like this it goes from looking like a short to an open and then again open to a short and so on ok because it follows that you know whatever $\tan \omega t d$ ok.

So, you can think of this therefore, as I mean if you see an impedance which is an open circuit you know can you think of a simple impedance which becomes an open circuit at a certain frequency.

Pardon. A parallel LC network can you think of a network that becomes a you know short at a certain frequency a series LC network. So, you can think of this transmission line terminated with a short circuit as a combination of whole bunch of parallel LC and parallel and series LC networks ok.

So, and because the extent of the transmission line is infinite you have an infinite number of such networks right the order of the network is actually infinite. Because the transmission line as you can see is made within, I mean you can think of it as infinitesimally many, infinitely many infinitesimal L's and C's ok.

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So, in other words this network is a high order frequency selective network alright. And likewise, the source which needs to be connected here it also basically as far as the you think that you have a short circuit. But, because of the length of the transmission line this also looks like a high order frequency selective network right.

And if the device under test for example, is has got some Y parameters Y_{11} , Y_{12} , Y_{21} and Y_{22} ok. What comment can we make about the gain of the network? We have all seen this in Analog electronics right. Why Y_{12} basically quantifies?

Y_{12} . It quantifies the feedback that is inherent inside that device under test right if there in a transistor you know that the gate drain capacitance basically results in a finite Y_{12} . Likewise in a bipolar transistor the collector-based capacitance results in non zero Y_{12} ok.

So, Y_{12} represents you know feedback inside the device right. It could be an amplifier if you have you know a big amplifier then you are sure I mean you will have it will have it

is own Y_{12} . But this, but it is all eventually boils down to you know reverse transmission within an active device ok.

And if you remember your analog electronics class from many years ago. You know that the transfer function will be you know will be you know some complicated formula in the numerator divided by. What do you have in the denominator?

1 minus. I mean why did we say when we derived you know what the transistors Y parameters must be? We said you know remember that denominator was $Y_{11} + Y_s$ plus Y_s times you know $Y_{22} + Y_L$ right minus Y_{12} , Y_{21} .

$$\frac{\dots}{(y_{11} + y_s)(y_{22} + y_L) - y_{12}y_{21}}$$

And there is some numerator on top right ok. And we said whenever we have an active network and I mean we wanted our device to have Y_{12} equal to 0. If not what would happen?

Yeah. So, basically you know Y_{12} is represents feedback. And so intuitively what you can think of is that well you excite this network well it puts out it for instance injects say some current here. Now, that current is basically is amplified by some block which is very highly high order network right which is also very frequency selective and some part of it is fed back right.

And so, therefore, if you think of the loop gain you can think of it as being proportional to this quantity Y_{12} times Y_{21} times whatever you know impedance that you see here ok. So, it is we will continue in the next class, but it is easy to see that this feedback system will have is a high order loop gain right with multiple poles.

And in principle you know a gain which can go to infinity because the load is because the load can become at some frequencies can become an open circuit and some frequencies you know is short and does all sorts of strange things. So, if you have a loop gain function which a high order loop gain function with high gain what comment can you make about such a feedback system.

I mean likely to go unstable is an understatement right in all probability it would be it will be unstable right. So, when people try to measure you know say active devices you know

try at high frequencies and try to you know kind of use cables and then say ok, I am going to short the end of the cable they found out that oh well all their transistors are the whole system is oscillating right.

Sometimes things are dangerous because oscillation amplitude can become so large that there is a lot of heat is generated in the device and the device burns up right. So, trying to terminate the transmission line with a shorter an open circuit is basically a recipe for disaster right ok.