Analog Circuits

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Module - 02
Lecture – 02

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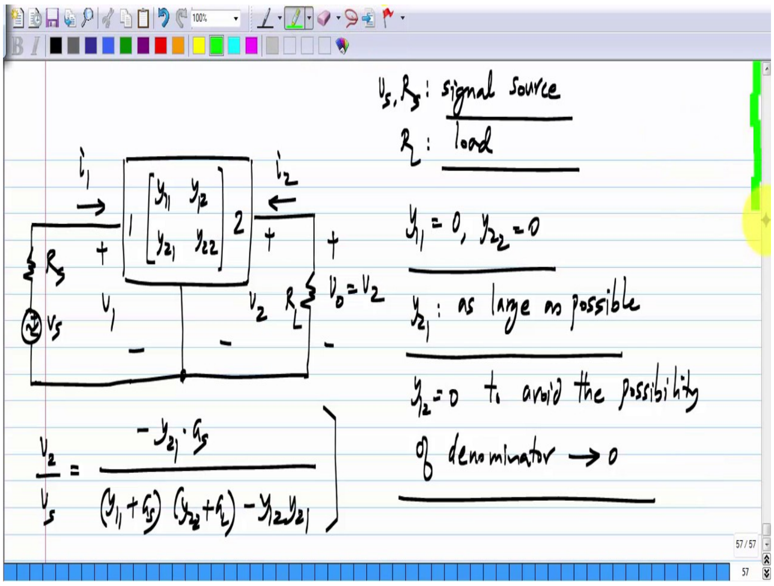

We evaluated the gain of two port; to one side of the two port, to port one, we connect a signal source, which is modeled by a voltage source in series with a resistance. And to the other side, we connect a load, which is modeled by a load resistance – R_L. And the expression for the voltage gain, we obtained was this one. So, now what we want to do is find out the constraints on y parameters, so that we maximize this gain. Now, V_S and R_S, these constitute in the signal source; so we have no control over R_S; R_S is given. We want to maximize the voltage gain regardless of the value of R_S. And R_L is the load, so this is also given and regardless of the value of R_L, we would like to maximize the gain. Now, from this expression, let see first of all G_S and G_L which are the load conductance and source conductance they are positive. And it turns out that y_{11} and y_{12} are also usually positive, it does not have to for a nonlinear two port, but we will consider them to be positive.

So, in that case, this y_{11} adds to the denominator, y_{22} adds to determine the denominator. So, to maximize the gain, clearly y_{11} has to be zero, and y_{22} has to be zero. Again so y_{11} and y_{22} add to terms in the denominator; so to maximize the voltage gain, these two quantities have to be as small as possible, and because we assume them to be positive, we will say that they have to be zero. This is quite simple to understand. And y_{21} appears only in the numerator, so clearly having a as large a value of y_{21} as possible will maximize the gain. So, y_{21} must be as large as possible. Now, the last remaining parameter is y_{12}, now this is little more subtle.

Now, first of all you can see that somehow if you make the product of y_{12} y_{21} equal to this whatever you have here, you could even make the denominator zero, and let the gain go to infinity. It turns out that this y_{12}, what is y_{12}, it is the effect of v_2 on i_1 that is the effect of port two on port one. Essentially within this two port network, there is feedback, there is some effect from port two to port one. Normally, if we think of it has an amplifier, apply an input to port one and take the output from port two. We do not expect the output to affect the input, but internally there is some effect that is given by this parameter y_{12}. Now, this, there effect of this it turns out can be quite complicated, because it depends on the values of G_S and G_L and so on. So, what you do not want is for this to cancel that and the gain to go to infinity. What does the gain of infinity mean, it means an unstable circuit; a circuit that can produce an output even without an input, so that is an unstable circuit and certainly something that we do not want.

So, although it is possible to play with the values of y_{12} in order maximize this expression that depends on the precise values of G_S and G_L and so on. So, we do not want to even get into that complication, the safest alternative is when y_{12} is zero that is internally there is no feedback. If you apply a signal to port one, it passes it onto port two, but if you apply a signal to port two nothing comes to port one that is the safest one. So, then this disappears completely and the denominator, you will have only these terms, which will be positive. y_{12} equal to zero to avoid the possibility of the denominator go into zero. So, broadly these are the constraint on the small signal parameters of the two port.

So, from this, we have to infer the large signal characteristic of the two port. Remember we have not taken any specific device, any particular amplifying device, we just assume that the device is described with currents as function of voltages and derived the constraints on the incremental parameters. By the way, you can also use other parameters that is if you have nonlinear device happens to have voltages described as functions of currents then you can derive the corresponding a small signal parameters which are z parameters and evaluate similar constraints. And you will come to similar conclusions that is that the forward parameter this y_{21}, what is y_{21}, it is the effect of port one on port two that should be as large as possible; and the feedback parameter, y_{12} that is effect of port two on port one should be as small as possible. Regardless of the parameters set you choose, it turns out these will be the constraints. It turns out that most of the real devices are well described by y parameters or with currents as functions of voltages that is why we choose them. But if tomorrow someone else invents a device which is different, you should still be able to work with them.