Analog Circuits
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Module - 03
Lecture – 14

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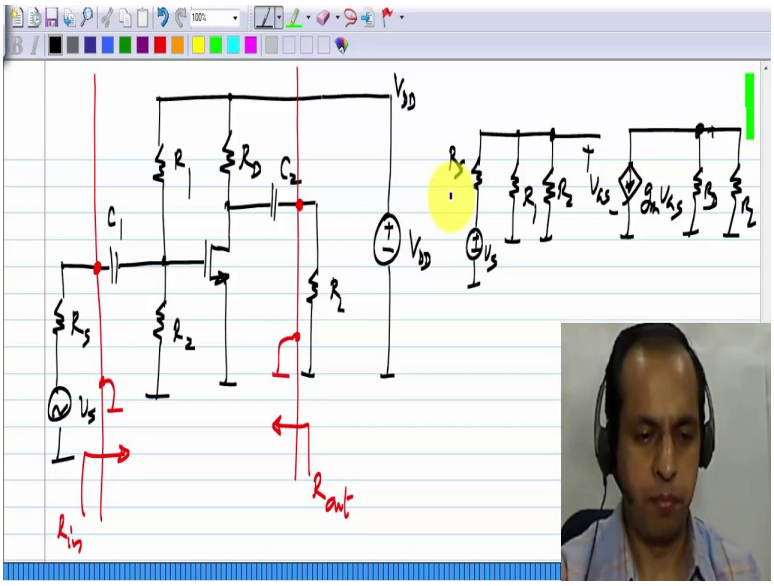

In the common source amplifier with drain feedback, while calculating the values of C_1 and C_2, we introduced the concept of input and output resistances of the amplifier. Now, let us go back to the original common source amplifier, the first one that we designed with a resistive divider to bias the gate source; and drain feedback resistor R_D to bias the drain. So, this sets the operating point. And we apply the input here through C_1 and take the output through C_2. And this is, of course, V_{DD} which means that there will be a supply voltage of value V_{DD} between that point and ground. So again for this as well, we can define the input and output resistances; the input resistance is between those two terminals across which you connect the input. The output resistance is between those two terminals across which you connect the load. So this is R_{out}; this is R_{in}.

Of course, here this is cutting only one terminal when it is like that it assumed that the other terminal is ground. Similarly here, it is between ground and the terminal.And as usual, we will

assume that the signal frequency is above as certain value and C_1 and C_2 are short circuit at that frequency. So, if I write the small signal equivalent of this, you can do this yourself; and by now you should be quite familiar with this. We will have R_1, R_2 between the gate of the transistor and ground; $g_m V_{GS}$, where V_{GS} is the gate source voltage and we have R_D and we have R_L. And the input is connected here.

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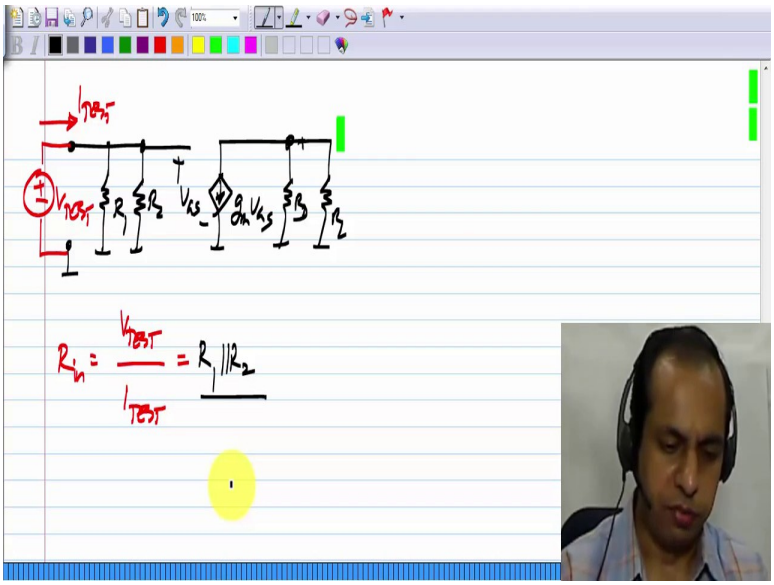

Now, for the input resistance what we do is remove the source; remember R_s is part of the source; we remove that as well, and look between this point and ground. So, essentially, we apply V_{test}, calculate the value of I_{test} and the input resistance would be V_{test}/I_{test}. Now in this particular case, you can calculate it; and it is very easy to see that it is simply equal to $R_1 \parallel R_2$. In fact, this is the case where the load resistance does not affect the input resistance. This is not generally the case, when you had drain feedback and the common source amplifier was built around that you saw that the input resistance was affected by R_L, but now it is not. So, the input resistance is simply $R_1 \parallel R_2$.

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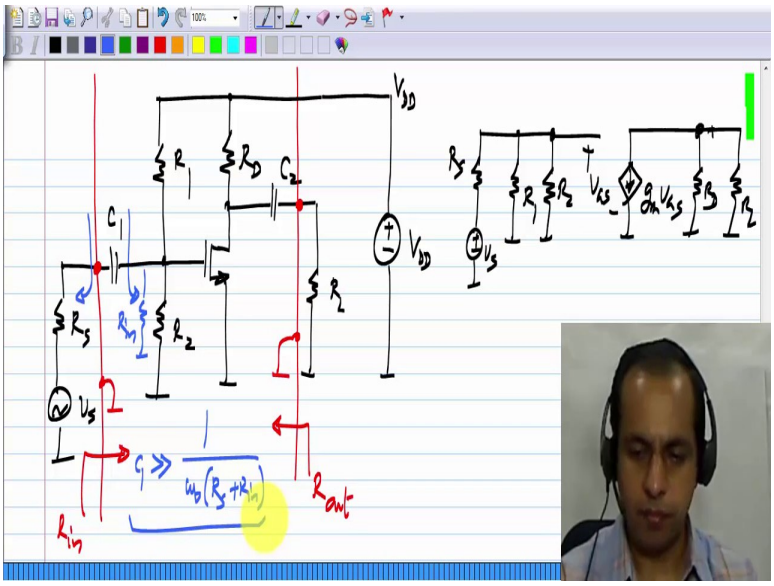

And just as before if you evaluate the constraint for C_1, what happens is one this side you have R_s, and on this side, you will have R_{in} of the circuit. And $C_1 \gg 1/\omega_0(R_s+R_i)$. That is the constraint.

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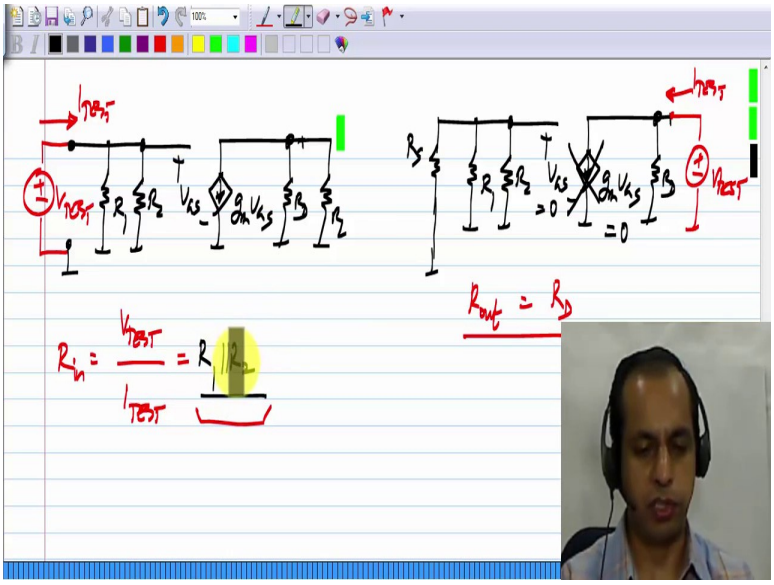

Now, coming to the output resistance, we measure it between the points where the load is connected. We apply V_{test} and measure I_{test}, and the source V_s would be set to zero meaning it would be replaced by a short circuit. Again this calculation is very easy; you see that because this is zero here this V_{GS} itself is zero, because this voltage V_{GS} appears across the parallel combinations of these three resistors and if there any non-zero V_{GS}, there will be no way for this current to flow, the gate is an open circuit right. So, V_{GS} will be equal to zero, which means that this current source $g_m V_{GS}$ is also zero meaning it becomes an open circuit. So, you can calculate this I_{test} and take the ratio V_{test}/I_{test} ., but it is very easy you will immediately see that the resistance looking back would be R_D. R_{out} equals R_D. So that is pretty easy for the common source amplifier with fixed V_{GS} bias. Now, typically an amplifier like this, you would want the input resistance to be as high as possible. Then, what happens is that there is no voltage division between the source resistance R_s and the input resistance.

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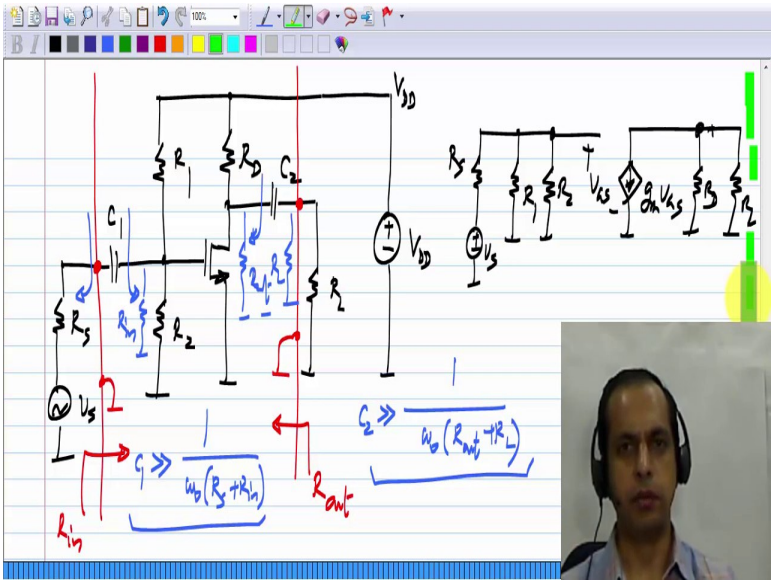

And as with the case of a common source amplifier with drain feedback, the constraint on capacitor C_2 would be that $C_2 \gg 1/\omega_0(R_{out}+R_L)$, because if you look at C_2 on this side you have R_L, and looking back that way you would have R_{out} whatever it is. And this is consistent with the conditions we have evaluated earlier even before we defined the concepts of input and

output resistances. The input and output resistances are quantities which you calculate for almost every circuit because those are parameters of interest. Now, it is important to remember that while calculating the input resistance, you should have the appropriate load resistance in place. The input resistance can depend on the load resistance. Similarly, while calculating the output resistance, the source resistance should be in place; the output resistance does depend on the source resistance.