Analog Electronic Circuits
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Lecture - 64
Frequency Response of the Common-Drain Amplifier

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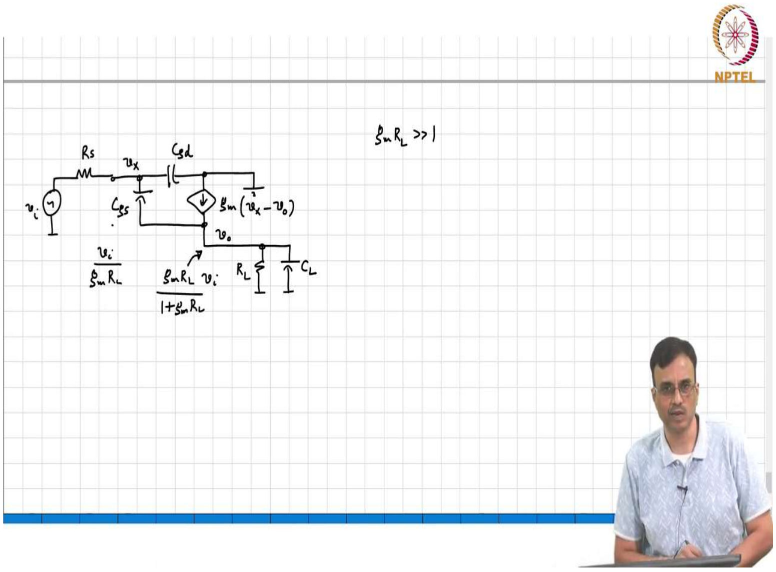

Then let us take a look at the other amplifiers that we have seen, namely the common drain. So, this is something that is v_i. This is R_L and let us say this is R_L and C_L this is C_{gs} and this is C_{gd} ok.

So, again we use the what do you call first order analysis, right after you can also you know you can also write you know full blown expression that will also turn out to be second order, right and without going through the algebra can you comment on whether we will have 0 in the right half plane or will have a 0 in the transfer function or no? Yeah, the one path through C_{gs}, one path through g_m, right ok.

So, it will be the 0 be in the right half plane or left half plane, yeah. So, basically through v_x, v_x is you know if you pull up v_x the output is this is v_o, v_o is getting pulled up right and g_m is also if v_x increases g_m is pushing current into v_o. So, both of them are moving in the same direction. So, you should expect to see what you call an LHP 0 right, ok.

So, what is v_o approximately at low frequency is approximately g_m R_L $v_i/(1 + g_mR_L)$ and remember you know for you to make a good common drain amplifier what comment can we make about g_m R_L? Usually in a good amplifier g_m R_L is much much larger than 1. So, what comment can you make about the voltage across the C_{gs}? It is approximately the voltage across C_{gs} is approximately you know v_i/g_m R_L. It is actually $1 + g_m$ R_L, but that is you know 1 is small compared to g_m R_L.

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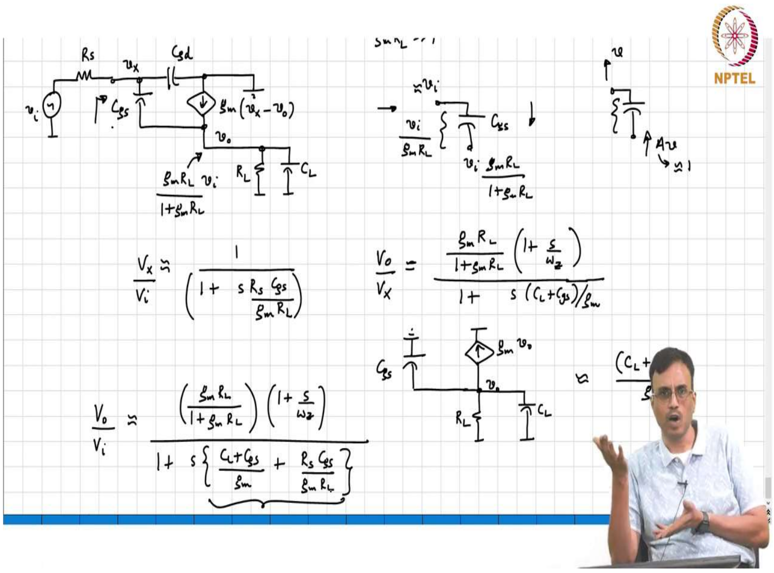

So, effectively what does C_{gs} look like? What is the effective capacitance looking in here ok. So, this is C_{gs}, this is v_x right which is approximately v_i at low frequency, this voltage is approximately v_i g_m $R_L/(1 + g_m$ $R_L)$, this is C_{gs} ok. So, what is the voltage across this capacitor man? So, that voltage is nothing, but v_i/g_m R_L ok. So, what is the current flowing to C_{gs}? So, what are they looking for in effective capacitance? C_{gs}/g_m R, you understand? Ok.

So, basically yeah you can see that I mean this is also like miller effect except that gain is 1. In the common source amplifier if this voltage went up by v, this voltage went down by A v where A was a large number. So, therefore, I mean that the C_{gd} appeared as if it was multiplied by (1 + A). This voltage goes up by v, this voltage is going up also by Av, but where A is approximately 1. If A is exactly equal to 1 then what happens? Even though v is going up, the other plate of the capacitor is also going up. So, there is no current voltage across the capacitor. So, no current will flow through it, correct. So, here the voltage is going up, but it is almost going. I mean it is going up by almost the same amount. So, therefore, the effective voltage across this capacitor is very small and consequently the current through the capacitor is very small and therefore, the looking in capacitance looks like a small fraction of C_{gs} and. So, therefore, v_x is therefore, first-order analysis V_x/V_i is nothing, but $1/(1 + sR_S C_{gs})/g_m R$. Does it make sense to people? ok. So, now, V_x to V_o what will be the denominator polynomial again? The numerator polynomial be? Think carefully this is going to be a numerator polynomial, let us forget about the numerator. What about the denominator? The denominator polynomial must only be independent of the value of V_x. So, what should you do? Now if you put 0 in place of V_x, what will you get?

This is C_{gs} that becomes 0 then what happens to that current source? That is V_o. So, this becomes g_m v_o and this becomes? What is the time constant associated with that node? So, the time constant which is greater than $1/g_m R_L$ is much much larger than 1. So, what is the time constant approximately $(C_L + C_{gs})$. So, therefore, the pole associated will be $1 + S (C_L + C_{gs})/g_m$ alright and there will be a 0. I let you go and calculate the value of the 0 and since I know nobody will calculate it right it will come in the exam. So, please go work it out in your ok. So, what is the; what is the total transfer function?

You multiply both these both these guys and you know for the same I mean for the same R_L when compared to a common source amplifier what comment can we make about the bandwidth of the common drain amplifier. So, V_0 this is V_0 by V_X $(1 + S)/\omega z/(1 + S C_L + C_{gs})/g_m + (R_S C_{gs}/g_m R_L)$, ok.

So, what comment can you make about this versus the same if you have the same R_S in the same R_L in the common source amplifier, what comment can we make about this time constant versus that time constant? This time constant is significantly smaller than the time constant associated with the common source and why does that make intuitive sense? Because remember that the gain the what gain are we getting here what incremental gain are we getting at DC you know is approximately 1. So, basically you can see that none of the voltages are swinging very much. So, that basically means that capacitors charging and discharging had to be charged and discharged only to a small amount, right whereas, in the common source amplifier the output node is swinging?

A lot of them basically means that the capacitors have to be charged and discharged. You know yeah you know a lot of charge is required which takes time to build and therefore, is equivalent to saying that the amplifier is slowed. You understand? Ok and as a general rule you know if you attempt to increase the gain right bandwidth will usually fall simply because of the reason if you want a lot of gain that basically means some nodes must swing very much. If they had to swing every node is associated with the capacitance if the voltage has to swing a lot it takes time I mean more charges to be pumped into that node right to pull that capacitor voltage up by a larger value and therefore, you know it takes a longer time which is equivalent to saying that the bandwidth is reduced ok alright ok.

So, with this I will stop. We will continue tomorrow.