Analog Electronic Circuits
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Lecture - 30
The Transimpedance amplifier (contd)

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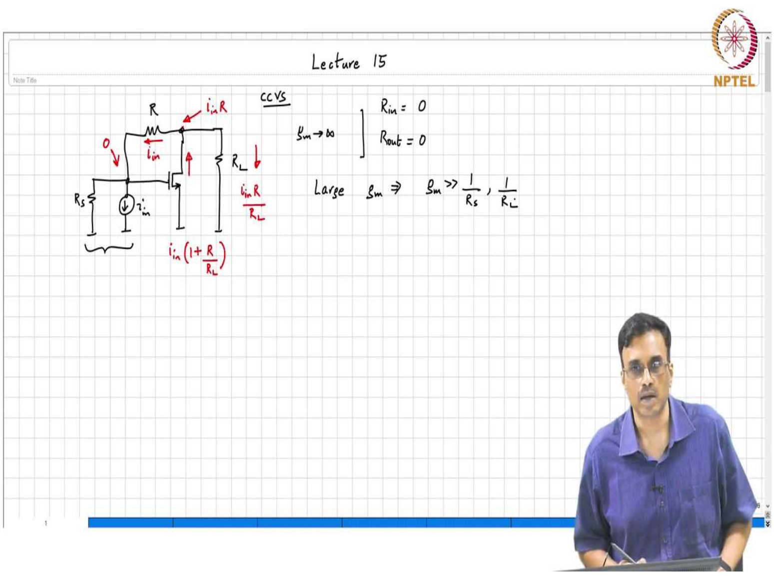

Good evening everybody and welcome to Analog Electronic Circuits, this is Lecture 15. In the last class we looked at the voltage controlled current. So, I mean current control voltage source where the incremental picture looked like this. This is i_n, this is R_L and if you assume that the current source has some internal resistance R_s then if g_m tends to infinity, what comment can we make about the input resistance?

Input resistance seen by the source here is 0, what comment can we make about the incremental voltage there? Incremental voltage there is 0, what comment can we make about the incremental current flowing there?

Student: i_n.

What comment can we make about the incremental voltage there? i_n R. What comment can we make about the incremental current flowing here? Why because the output voltage is i_n R. So, the current flowing in the load is i_n R / R_L. So, what is the current flowing in the transistor?

It is flowing in the opposite direction. If you want to avoid the negative sign that current is nothing, but i_n $(1 + R/R_L)$. Sanity checks if R_L tends to infinity all that current must flow into the transistor. So, does it make sense? Now, what comment can we make about R_{out}? When g_m is infinity it is 0 and so, what is the meaning of large g_m, g_m must be much much larger than?

Student: $1/R_s$.

$1/R_s$ and $1/R_L$ ok. So, that is pressure now we are going to position this is the incremental network we are now in a position to make the real thing and that is again you know you choose you pick your favorite biasing scheme, right.

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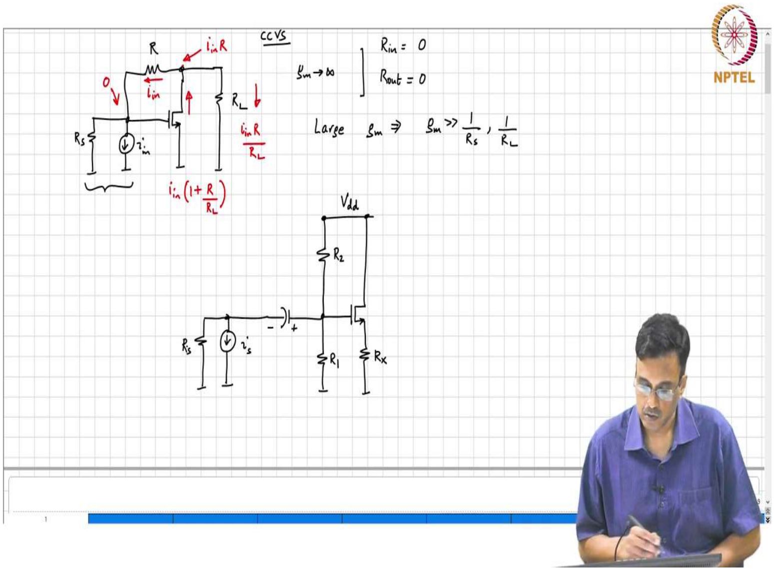

I am going to pick you know something for example, alright let me just pick something with gate voltage is constant, we measure at the source feedback at the source we use a poor man's current source and this is the V_{dd}, this is R_2, this is R_1 and this is some R_X. And the job of R_X is to reduce the, why do we have R_X there?

Why do we have R_X there?

Student: to reduce the source voltage.

To reduce what? How can adding a resistance series to this source reduce its voltage?

Student: It stabilizes the voltage and source.

Can somebody give you a more coherent answer? Yes, Ralph?

So, R_X basically does attempt to do whatever it takes to keep the current in the transistor constant of course, it works only when R_X is large and what is the meaning of R_X being large? What is a large R_X?

R_X should be much much larger than $1/g_m$ ok. With all those conditions satisfied I mean this stabilizes the bias current pretty well alright. So, now, we need to make the incremental network look like the one shown on top. So, what do we do?

Ok. So, i_s R_s straightforward ok, what else?

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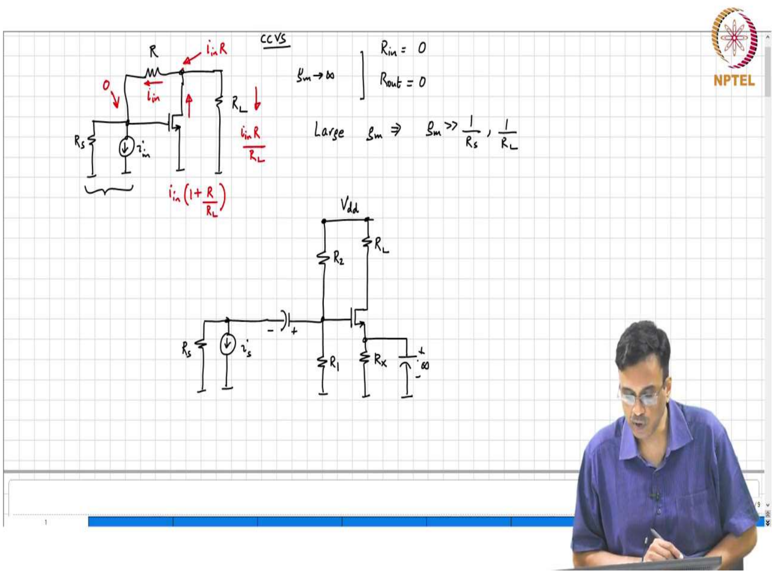

So, the load has multiple ways of doing it is to just put in the drain. What else?

The source must be?

Student: Ground rate.

Ground rate, so what do we do?

Student: Infinite capacitor.

Put an infinite capacitor, alright. Have we done it?

In the incremental network we see that the drain and the gate are connected to a resistor R. So, what do we do here?

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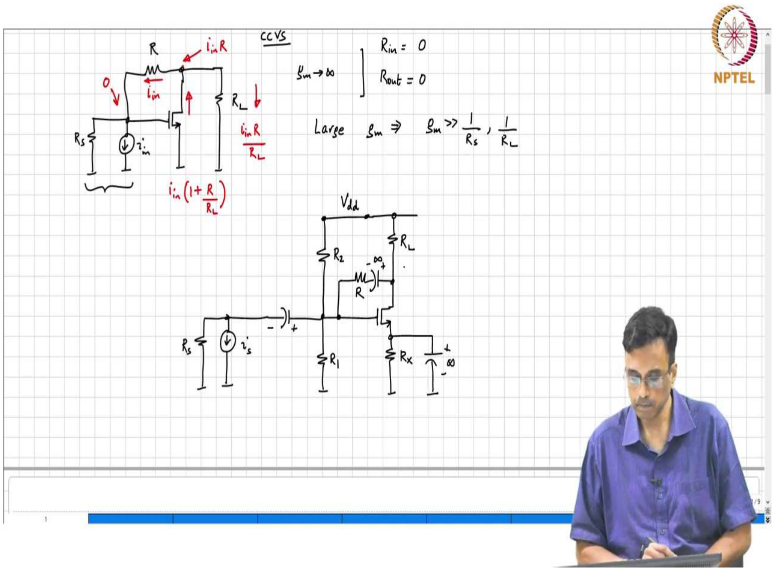

So, that is a transistor. So, what do we do with R? One way of doing it is to use an infinite capacitor to put R. What happens if I do not put a capacitor? Depending on the choice of R_1, R_2 and R_L a current could flow between through the resistor R and thereby disturb the operating point of the transistor, alright. So, this is basically you know perfectly working current controlled voltage source and you know nothing basically as we discussed the last time.

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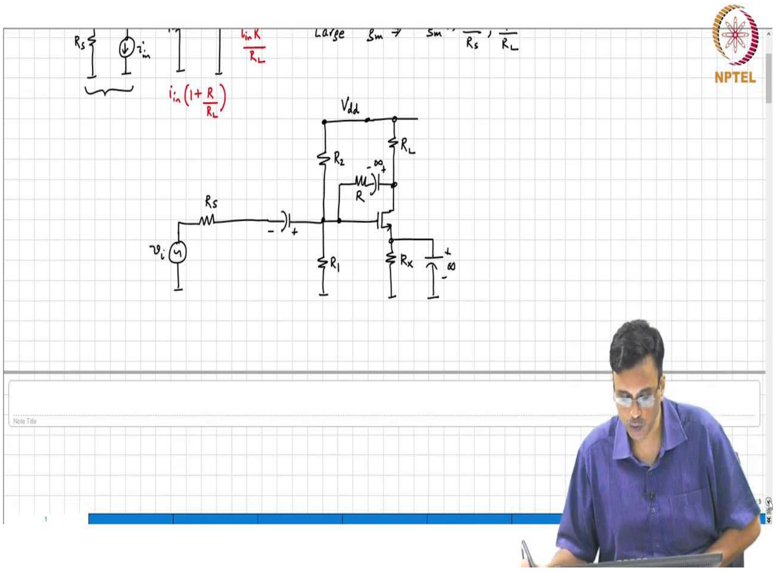

If this is v_i and this is R_s as g_m tends to win as g_m becomes very very large. What comment can you make about the incremental voltage at the output. What is the incremental voltage at the output -R/R_s v_i. I hope that is apparent. We spent a lot of time in the last class alright. So, basically, I mean if you want to impress your friends you can draw the draw big circuit like this right and you can by simply staring at the picture without doing any math right you can be sure that the gain is going to be approximately -R/R_s, even the circuit looks quite complicated with you know half a dozen resistors and few capacitors and so on, alright, ok. So, that covers the current controlled voltage source.