Power Management Integrated Circuits
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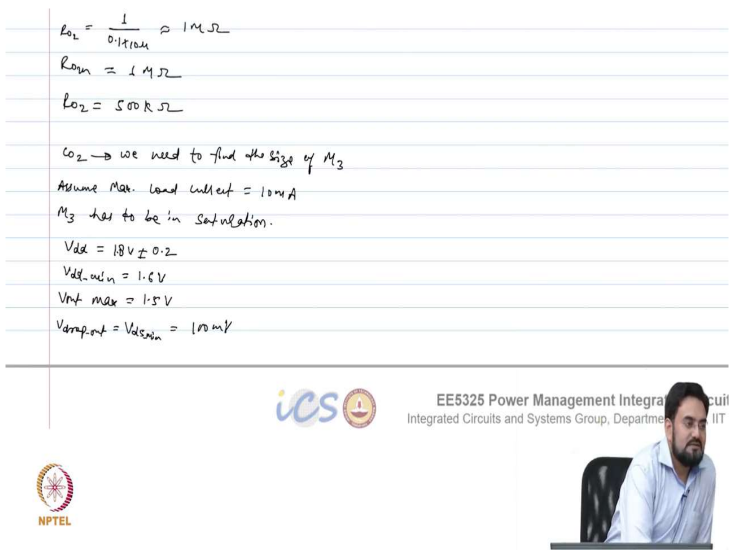
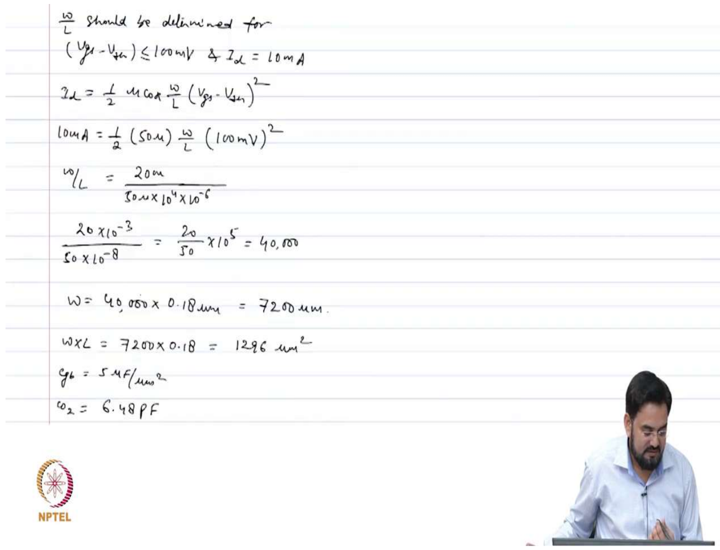
Lecture – 17
Finding the Poles of the Error Amplifier – Part 2

Calculating capacitance C_{o2} : First we need to find the size of pass element. And the size of this pass element is determined by the current requirement.



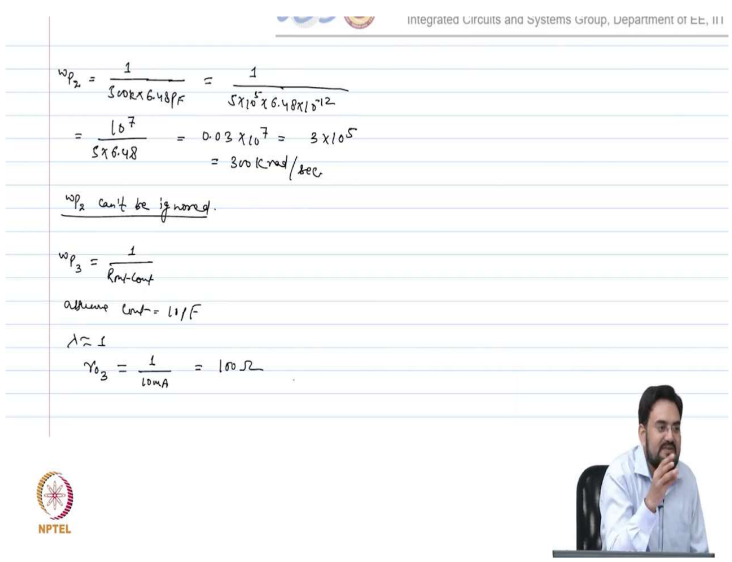
This pass element has to be in saturation. So, for the range of V_{dd} and V_{out} we have considered, the $V_{ds,min}$ is 100 mV. We know that the condition for saturation is $V_{ds} > V_{gs}$-V_{th} . And in order to reduce V_{gs}-V_{th} we have to increase the size. Which means you have to size for a minimum V_{ds} required. That's why I am considering the minimum V_{dd} and maximum V_{out} because that will give you the minimum V_{ds} or minimum dropout voltage.

So, the size of pass element (value of $\frac{W}{L}$) should be determined for V_{gs}-V_{th} $\leq$ 100 mV and for I_D = 10 mA which is shown in below figure.



For power FETs we usually keep minimum channel length, otherwise your area will be bloated, and your chip size will be very huge.

So, C_{o2} we are getting as 6.48 pF and we know that R_{out} is also large at this node. So, ω_{p2} can't be ignored.



Third pole is at the output which is due to C_{out}. Basically this C_{out} is not a fixed cap and this is an external cap which you need to put at the output. It could be order of picofarad or microfarad you never know. So, we have to assume a value to start with. Usually we put this C_{out} as minimum order of 10s of picofarad to maximum could be anything like even microfarad.

Let us assume C_{out} equal to 10 pF. And R_{out} will be mostly determined by your load current. So, 10 mA and if your output is 1.5 V then R_{out} is 150Ω.

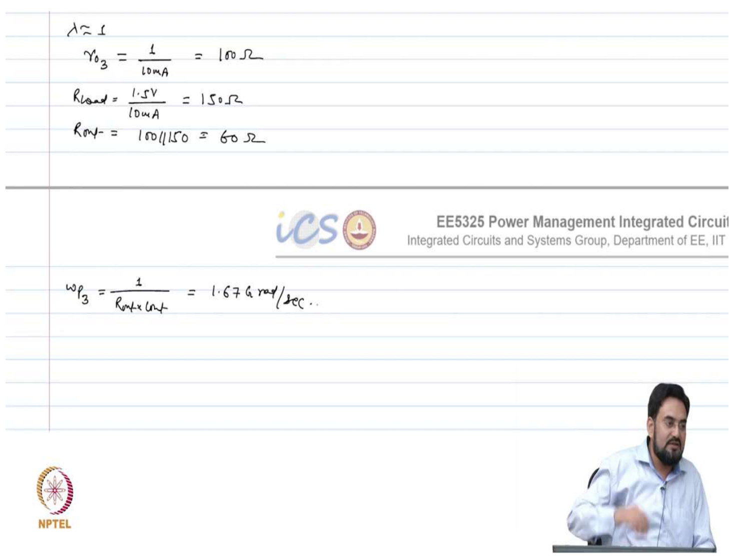
Student: Sir, practically R_{ds} is not neglected.

At this high current R_{out} will be mostly determined by load current. When you have a low current then R_{ds} will start coming into picture.

Let's calculate in that way. Since pass element is a minimum channel length device, so if I consider channel length modulation (λ) is approximately 1, then $r_{o3} = \frac{1}{\lambda I_D} = \frac{1}{10\ m} = 100\Omega$.

Now, if you consider load as a resistive then you have to take it into parallel. If you consider it as a current load, then resistance will be very high. So, in the current load the resistance looking into the drain might be much higher because you do not know what kind of current source it will be there.

There are two assumptions here. You can consider load as resistive or current load but in both the cases your resistance will be much lower like it can't be even Kilo Ohm for 10 mA current. So, if you consider resistive load, then it will become 100Ω parallel with 150Ω.



So, ω_{p3} we get as 1.67 Grad/sec which is even higher than your first pole (ω_{p1}).