MOS Small-Signal Model, PMOS Device

zrrraa

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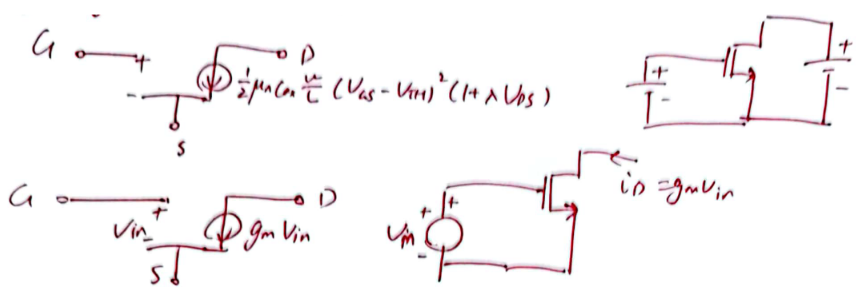
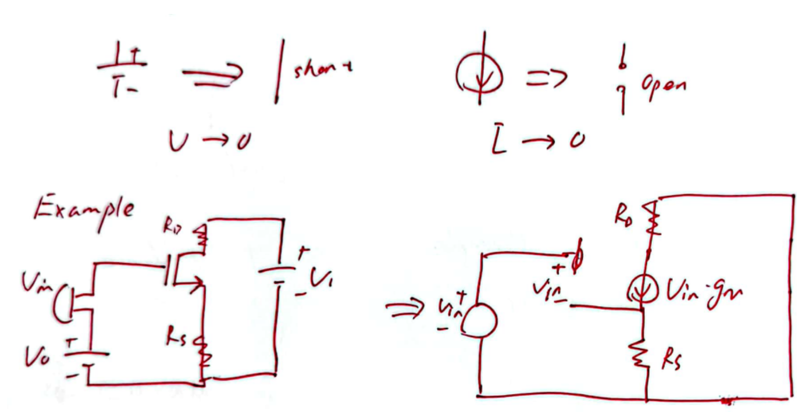
Large-Signal & Small-Signal Operation



Large-Signal & Small-Signal Operation

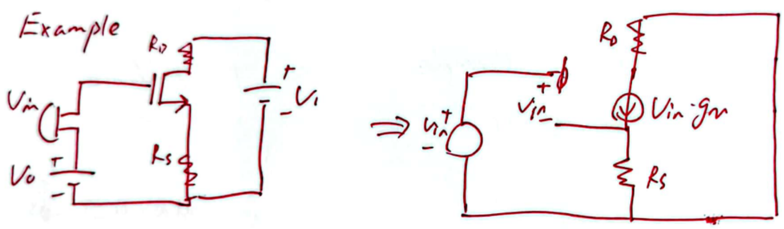
Small-Signal Models of Const Sources

In const sources, we make all constants equal 0.



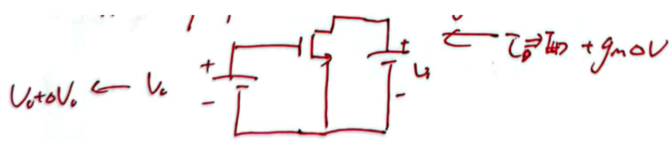
Small-Signal Models of Const Sources

Here's a example.



General Procedure of Constructing a Small-Signal Model

- Apply proper bias voltages to the device.
- Increment the voltage difference between two terminals.
- Measure all current increments.
- Model the change by a proper electrical device.



Increment of V_{GS}

In the second point above, we want to study the effect of the voltage increment at the two terminals on the circuit. Let's take a look at the impact of increasing V_{DS} on the circuit.

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$$

Now we take consideration of the Channel-Length Modulation, so the increment of V_{DS} leads to the increment of I_D.

$$I_D + \Delta I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS} + \lambda \Delta V_{DS})$$

$$I_D + \Delta I_D = I_D + \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2 \lambda \Delta V_{DS}$$

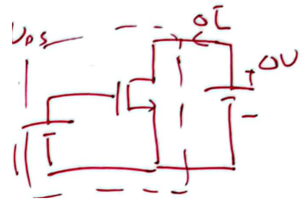
Here we regard $\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2$ approximately as I_D.

So we can get:

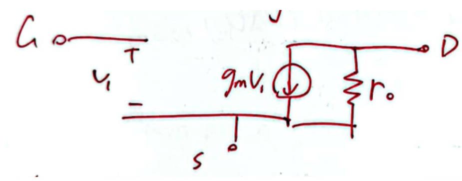
$$\frac{\Delta V_{DS}}{\Delta I_D} \approx \frac{1}{\lambda I_D} = r_o$$

We think of the connection between drain and source as a resistor.

Neglect the effect of Channel-Length Modulation on the g_m expressions. Here's the small-signal model with r_o.

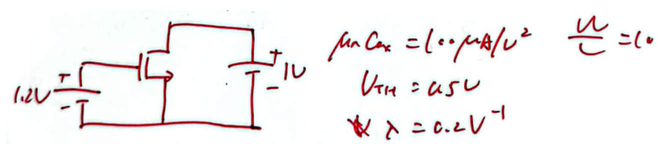


Think of the connection between drain and source as a resistor



Small-Signal model with r_o

Example



$$V_{GS} - V_{TH} \leq V_{DS} \implies Saturation$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2 \implies r_o = \frac{1}{\lambda I_D} \implies r_o = 20.4k\Omega$$

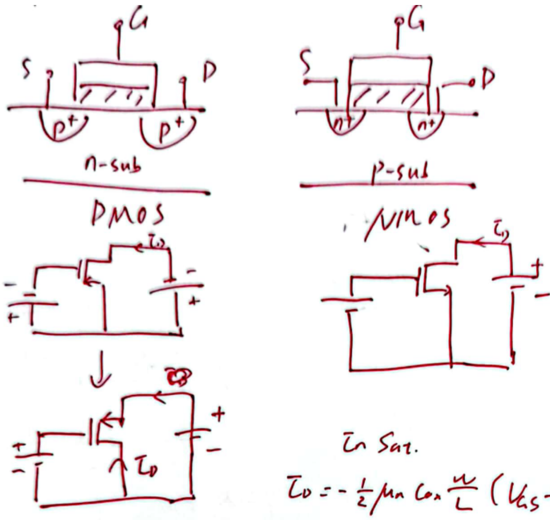
$$g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH}) = \frac{1}{1.43k\Omega}$$

PMOS

For PMOS:

- $V_G < V_S$
- $V_{TH} < 0$
- $V_D < V_S$

In PMOS, the current flows from Source to Drain.

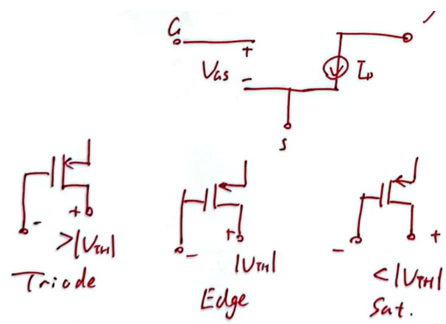


In Sat.

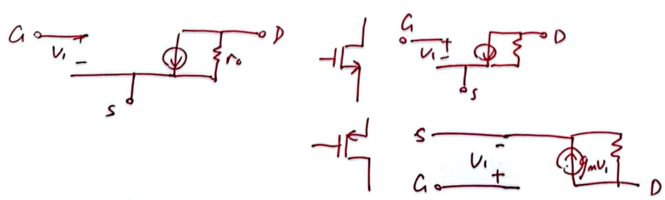
$$I_D = -\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2(1-\lambda V_{DS}) \quad (\lambda>0)$$

Large-Signal Model

Pay attention, I_D is still defined from Drain to Source. So it's minus.



Small-Signal Model



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