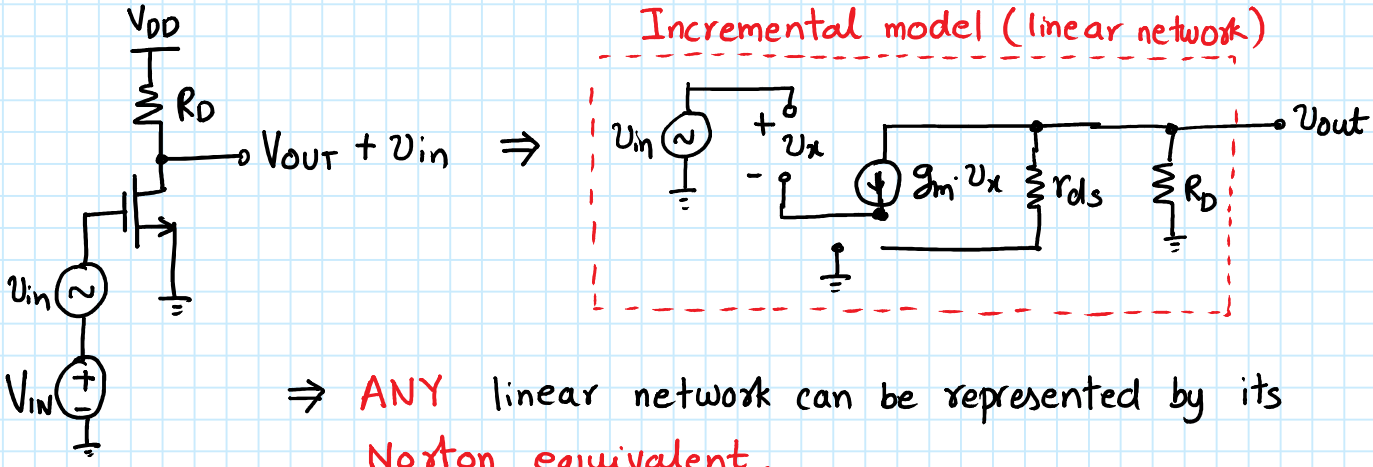
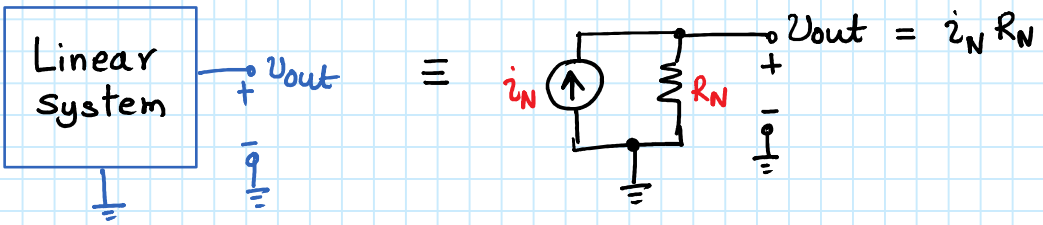
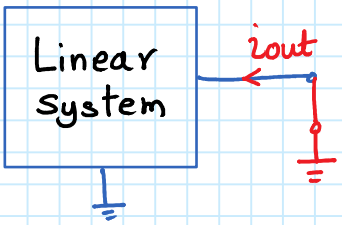
Lecture 15 [Alternate gain calculation method]



⇒ ANY linear network can be represented by its Norton equivalent.

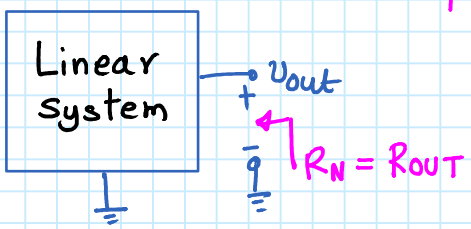


i_N : Short circuit output current



$i_N = -i_{out}$

R_N: Impedance looking into output port



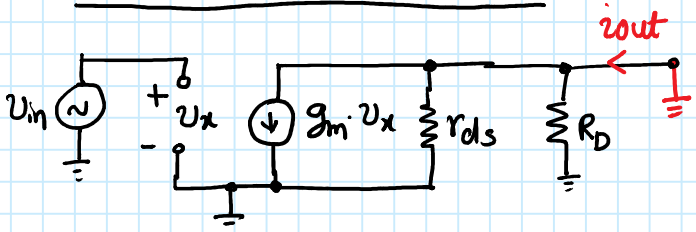
Represent $i_{out} = G_M \cdot v_{in}$ where $G_M = \left.\frac{i_{out}}{v_{in}}\right|_{v_{out}=0}$

G_M : Short circuit transconductance

$$v_{out} = i_N R_{OUT} = -i_{out} R_{OUT} = -G_m \cdot v_{in} R_{OUT}$$

$$\Rightarrow \boxed{A_V = \frac{v_{out}}{v_{in}} = -G_M R_{OUT}}$$

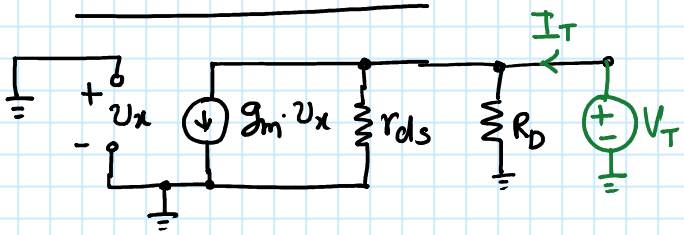
Application to CS stage:



$i_{out} = g_m \cdot v_{in}$

$$\Rightarrow G_M = \left.\frac{i_{out}}{v_{in}}\right|_{v_{out}=0} = g_m$$

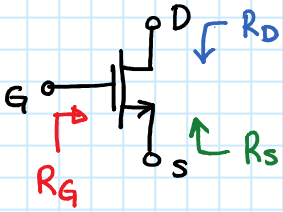
R_{OUT} calculation:



$$R_{OUT} = \frac{V_T}{I_T} = r_{ds} \parallel R_D$$

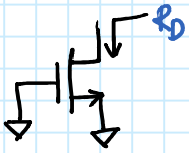
$$\therefore A_v = -G_M R_{OUT} = -g_m (r_{ds} \parallel R_D)$$

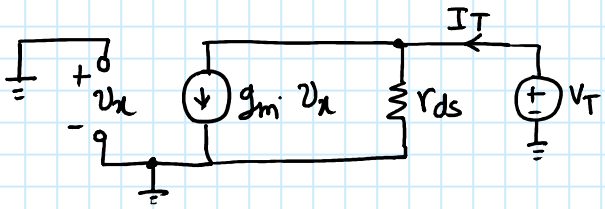
MOSFET terminal impedances:



Impedance looking into gate: $R_G = \infty$

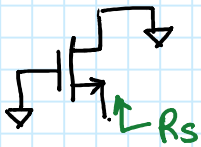
Impedance looking into drain: R_D when gate & drain are at incremental ground

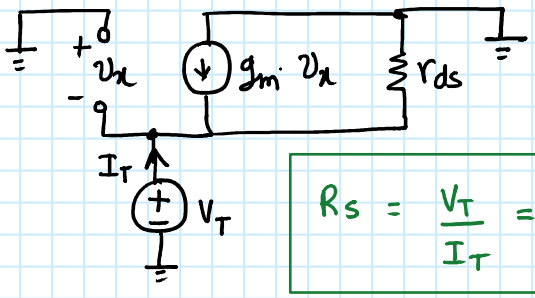




$$R_D = \frac{V_T}{I_T} = r_{ds}$$

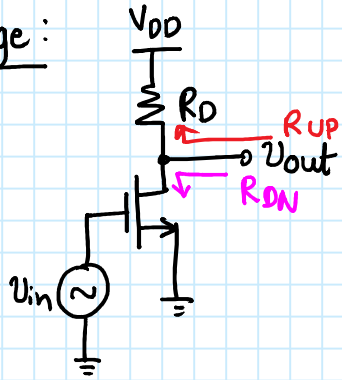
Impedance looking into source: R_S when gate & drain are at incremental ground





$$R_S = \frac{V_T}{I_T} = \frac{1}{g_m} \parallel r_{ds} \approx \frac{1}{g_m} \text{ if } g_m r_{ds} >> 1$$

Revisit CS Stage:



$$G_M = g_m$$

$$R_{OUT} = R_{UP} \parallel R_{DN}$$

$$R_{UP} = R_D \qquad R_{DN} = r_{ds}$$