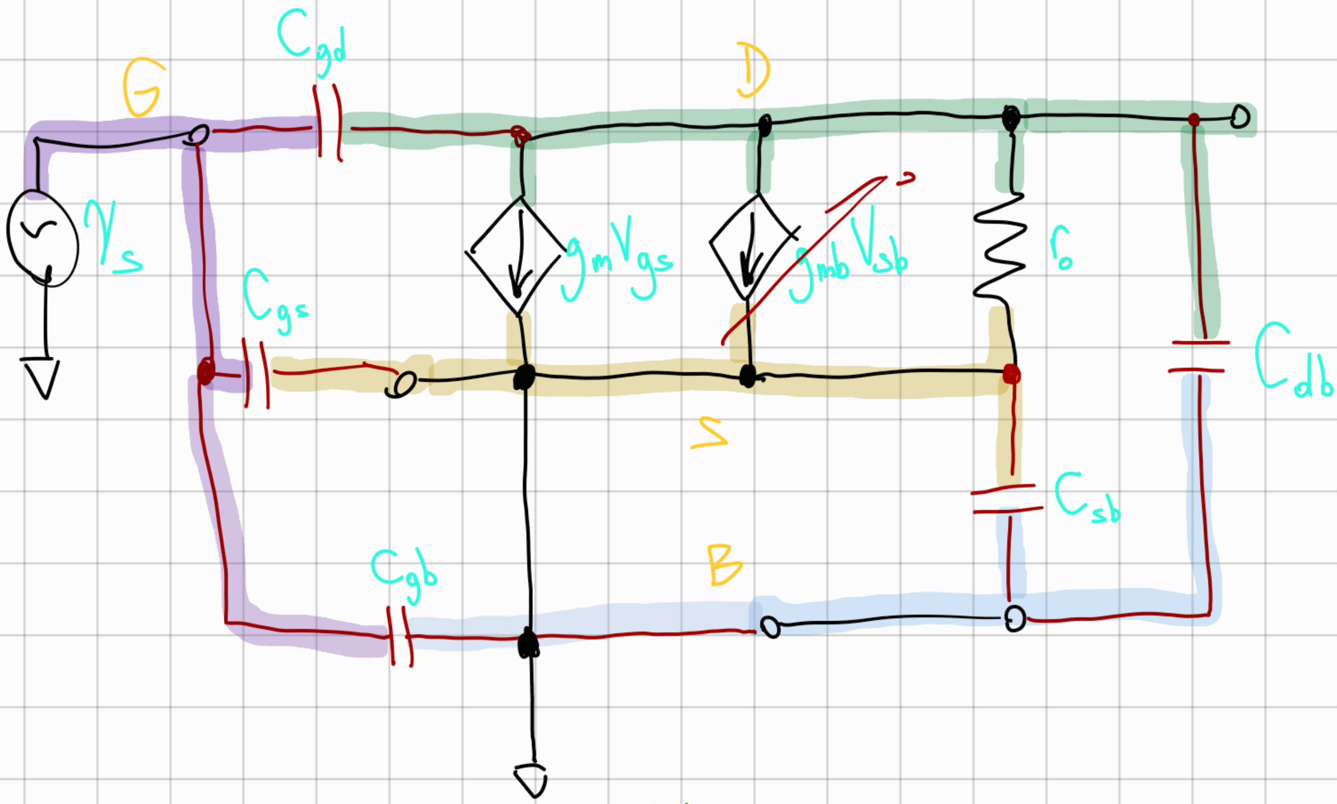
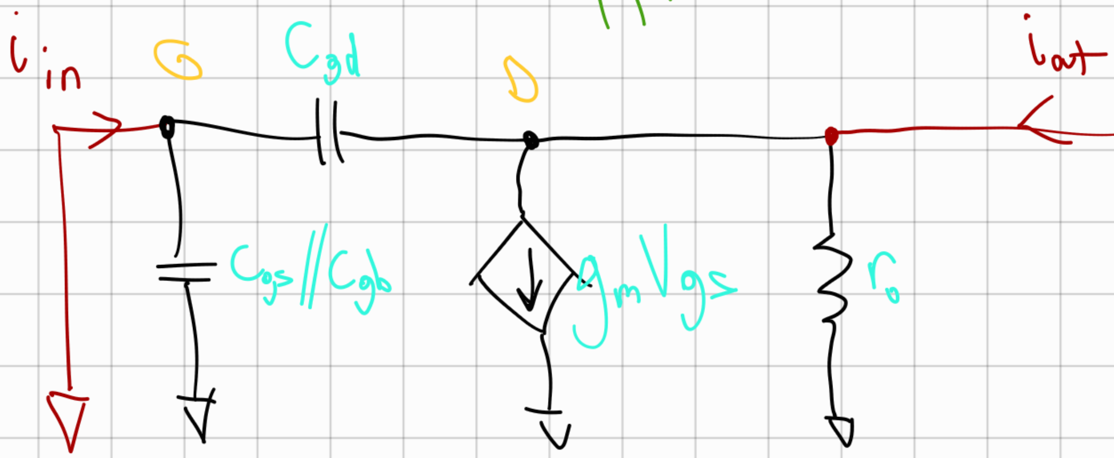
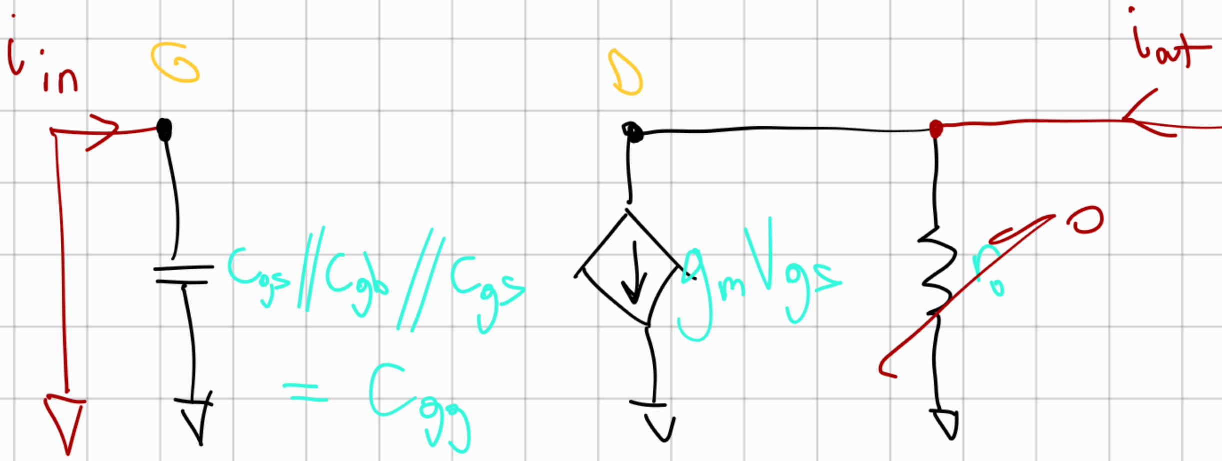
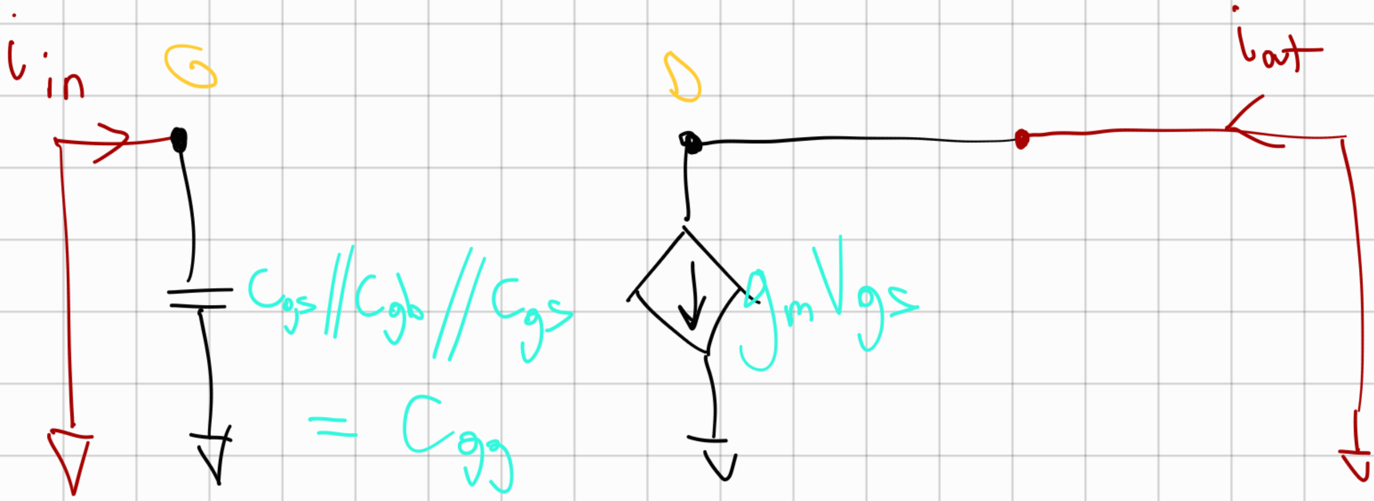
Small-signal Model







Simplified Small-signal Model



$$* \quad i_{in} = \frac{V_g}{sC_{gg}} \quad \& \quad i_{out} = g_m V_g$$

$$\Rightarrow \frac{i_{out}}{i_{in}} = \frac{g_m \cancel{V_g}}{\frac{\cancel{V_g}}{sC_{gg}}} = \frac{g_m}{sC_{gg}}$$

$$\Rightarrow \left| \frac{g_m}{sC_{gg}} \right| = \frac{g_m}{2\pi C_{gg}} = 1 = f_T$$

$\square$

g_m/I_D Systematic Design Methodology

1) From the design specs and constraints, determine g_m.

2) Pick L: (a) Short-channel → high f_T, small area
(b) Long-channel → high A_v, large area

3) Pick g_m/I_D: (a) Large g_m/I_D → Low power, high A_v
(b) Small g_m/I_D → High f_T, small area

4) Determine I_D using steps 1 and 3.

5) Determine W using I_D/W denormalization.

$$g_m = \sqrt{2\mu C_{ox}\frac{W}{L} I_D} \qquad r_o = \frac{1}{\lambda I_D}$$

$$A = g_m \cdot r_o = \frac{1}{\lambda}\sqrt{\frac{2\mu C_{ox}\frac{W}{L}}{I_D}}$$