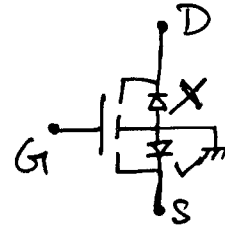
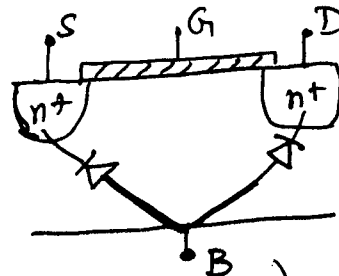
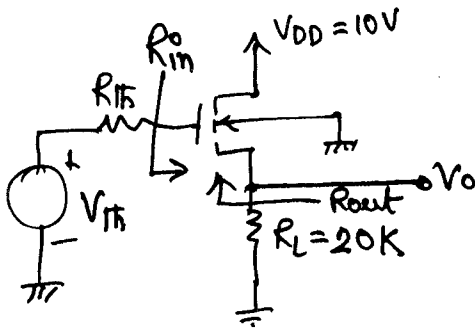
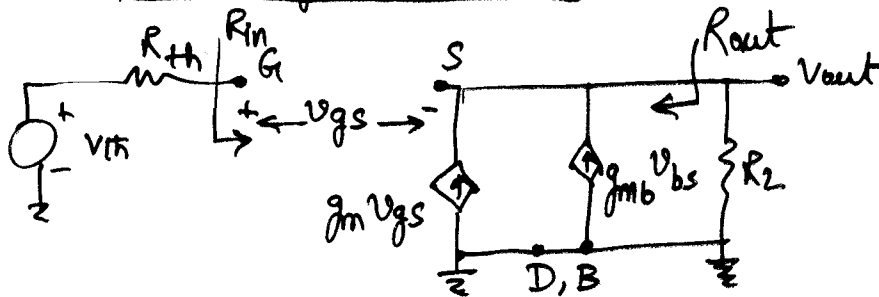


Source Follower with Bulk Effect



$K_n = 500 \mu A/V^2, V_{TN} = 1V, \lambda = 0$
 $\gamma = 0.75 V^{1/2}, 2\phi_f = 0.6 \quad (\tau_0 \rightarrow \infty)$
 Q point: $I_{DS} = 241 \mu A, V_{O1} = 5V_{DC}$

Small-signal model



$$g_m = \sqrt{2 K_n I_{DS}} = \sqrt{2 \cdot 500 \cdot 241} = 491 \mu S$$

$$g_{mb} = \frac{\gamma \cdot g_m}{2 \sqrt{V_{SB} + 2\phi_f}} = \frac{(0.75)(491)}{2 \sqrt{5 + 0.6}} = 77.8 \mu S$$

$$\left(\frac{V_{out}}{V_{in}} \right) = ??$$

$$\begin{aligned}
 V_{out} &= (g_m v_{gs} + g_{mb} v_{bs}) R_L \\
 &= [g_m (v_g - v_s) + g_{mb} (v_b - v_s)] R_L
 \end{aligned}$$

$$v_{out} = [g_m(v_g - v_{out}) + g_{mb}(0 - v_{out})] R_L$$

$$v_{out} = g_m R_L \cdot v_g - (g_m + g_{mb}) R_L v_{out}$$

$$v_{out}(1 + (g_m + g_{mb}) R_L) = g_m R_L \cdot v_g$$

$$v_g = v_{th}$$

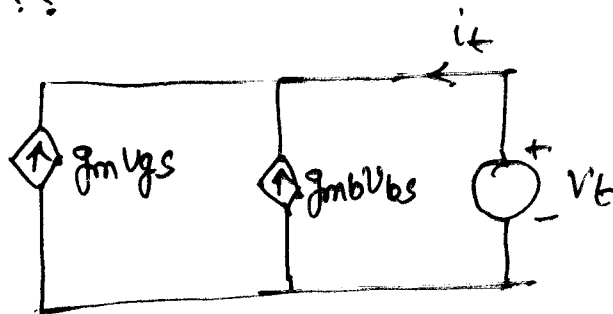
$$\frac{v_{out}}{v_{th}} = \frac{v_{out}}{v_{in}} = \frac{g_m R_L}{1 + (g_m + g_{mb}) R_L}$$

$$\left(\frac{v_{out}}{v_{in}} \right) = 0.793 \text{ V/V}$$

$$R_{in} = ??$$

$$R_{in} = \infty$$

$$R_{out} = ??$$



$$i_t = -g_m v_{gs} - g_{mb} v_{bs} = -g_m (v_g - v_s) - g_{mb} (v_b - v_s)$$

$$= -g_m (0 - v_t) - g_{mb} (0 - v_t)$$

$$i_t = (g_m + g_{mb}) v_t$$

$$R_{out} = \frac{v_t}{i_t} = \frac{1}{(g_m + g_{mb})} = 1.76 \text{ k}\Omega$$