14|10|2020

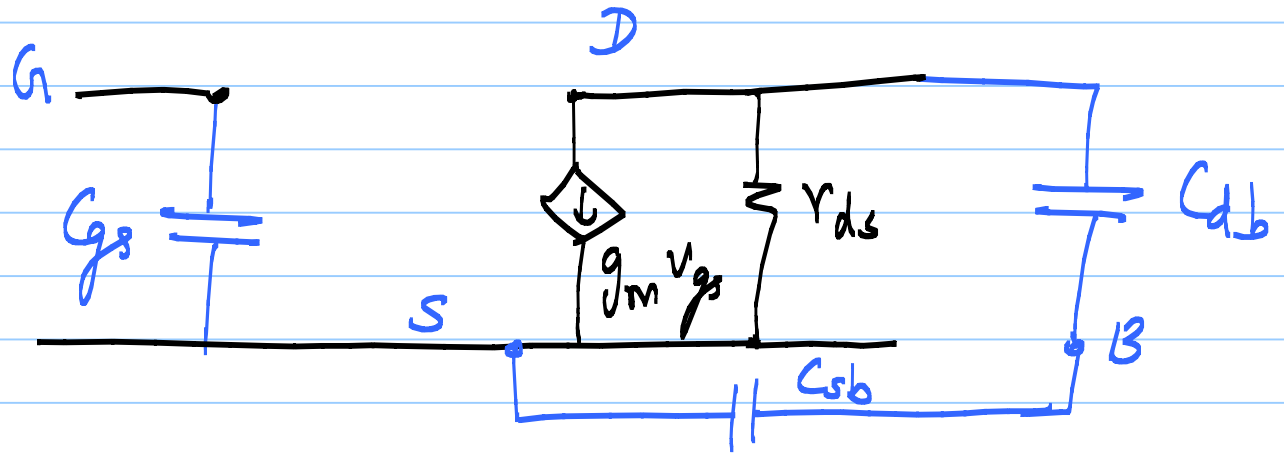
Lecture 38

* MOSFET caps — C_{gs}, C_{gd}, C_{db}, C_{sb}

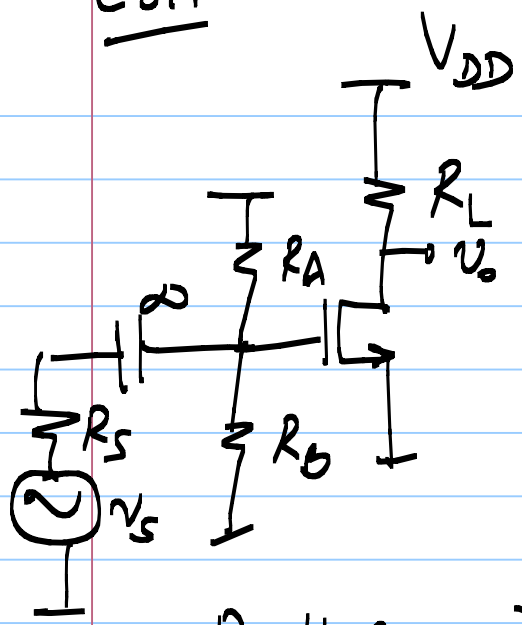
C_{gs}: largest, $\frac{2}{3} WL C_{ox}$

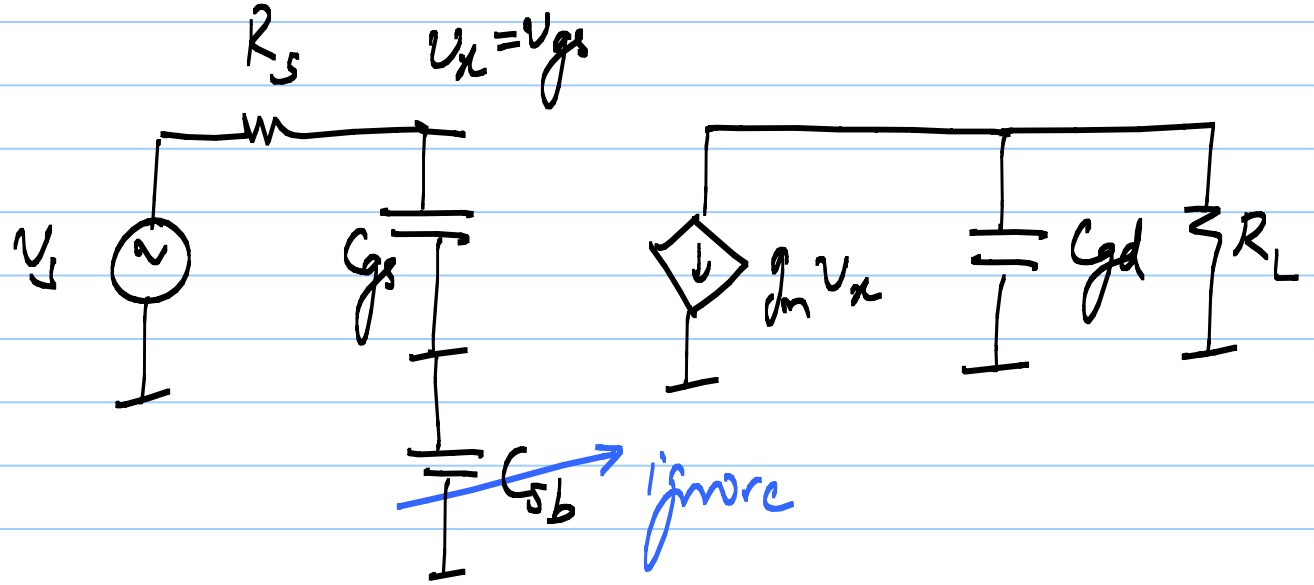
C_{gd}: smallest

1) Assume C_{gd} is negligible



CSA





$R_A \| R_B \gg R_S$

$$v_x(s) = \frac{1/sC_{gs}}{R_S + 1/sC_{gs}} \cdot v_s(s)$$

$$v_o(s) = -g_m \cdot \frac{1}{G_L + sC_{db}} \cdot v_x(s)$$

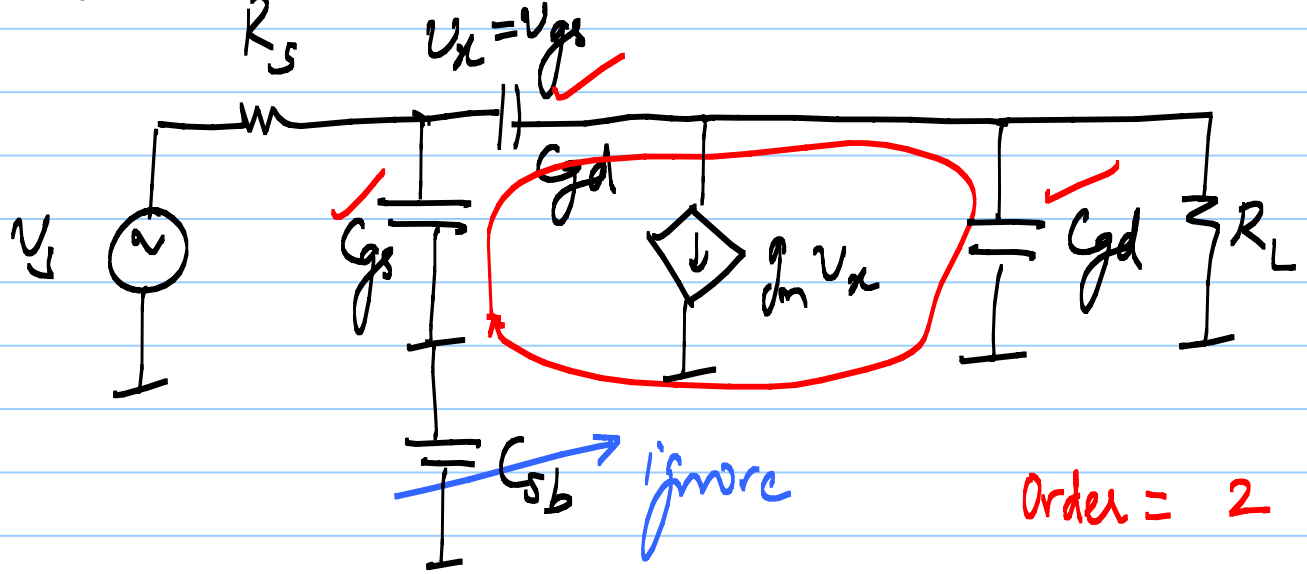
$$\frac{v_o}{v_s}(s) = \frac{1}{1 + sC_{gs}R_s} \cdot \frac{R_L}{1 + sC_{db}R_L} \cdot -g_m$$

$$\frac{v_o}{v_s}(s) = (-g_m R_L) \cdot \frac{1}{(1+sC_{gs}R_s)(1+sC_{db}R_L)}$$

input pole: $p_1 = -\frac{1}{R_s C_{gs}}$

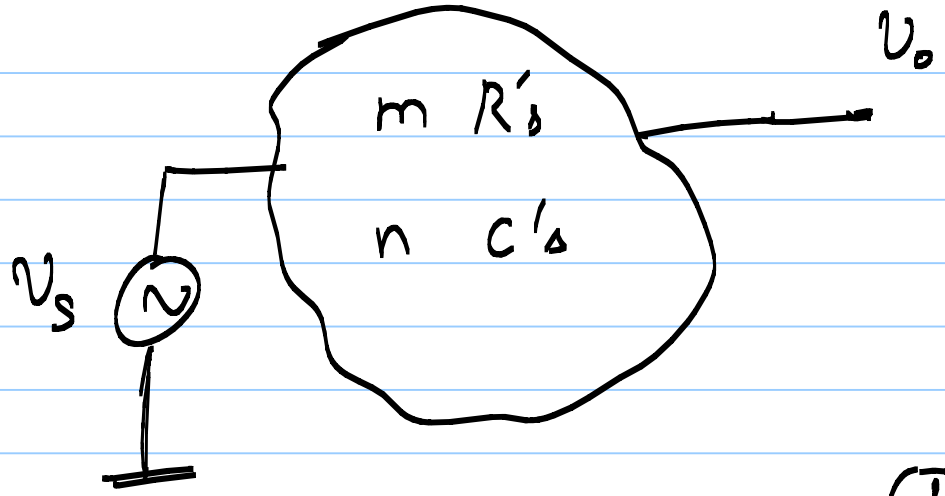
output pole: $p_2 = -\frac{1}{R_L C_{db}}$

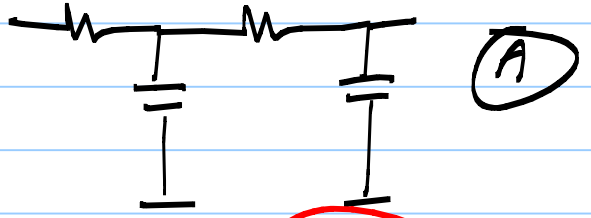
2) With C_{gd}:



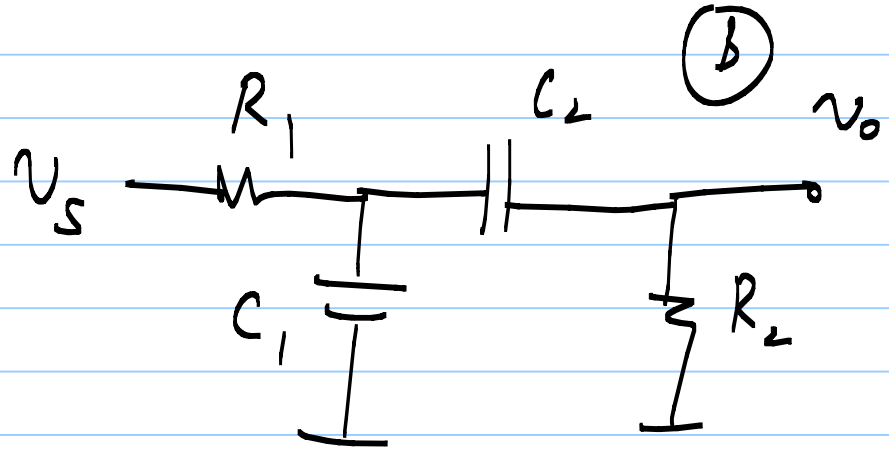
Order = 2 { D(s) quadratic }

2 poles + 1 zero



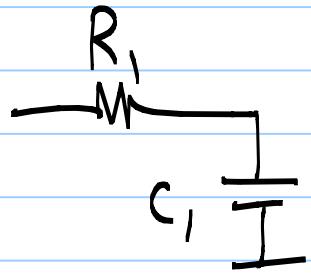


$$\frac{v_o}{v_s} = \frac{N(s)}{D(s)}$$

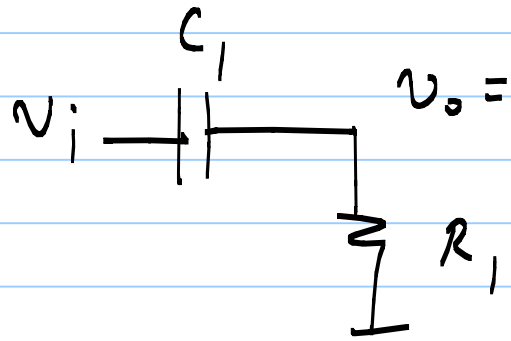


order = degree of $D(s)$

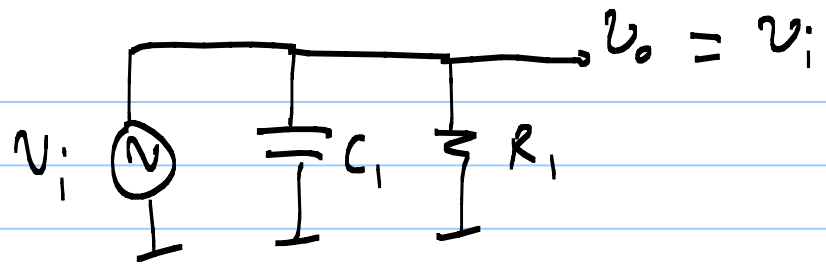
1 cap. $\Rightarrow$ order = 1



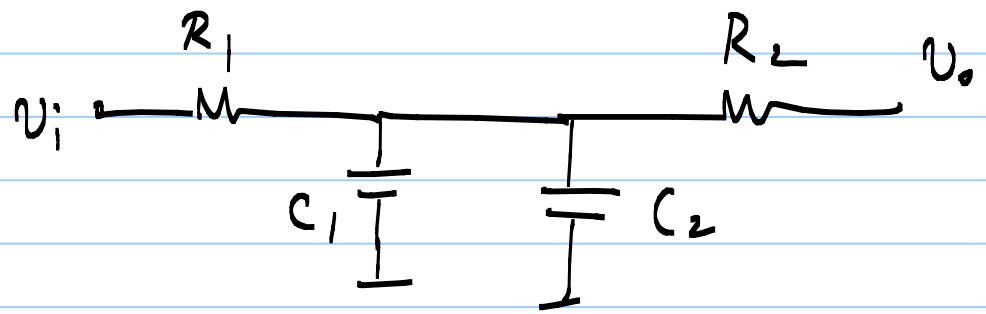
or



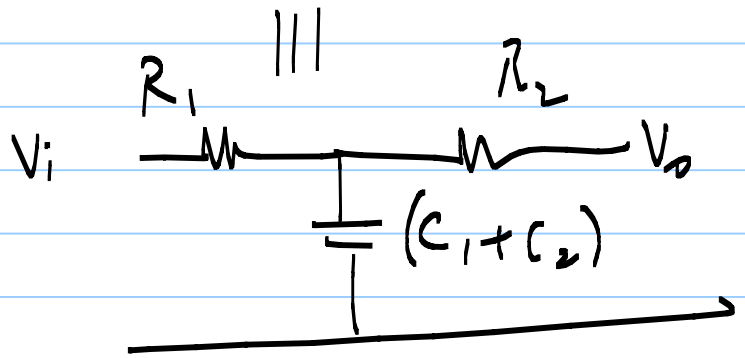
$$v_o = \frac{sC_1R_1}{1+sC_1R_1}$$



order = 0



order = 1



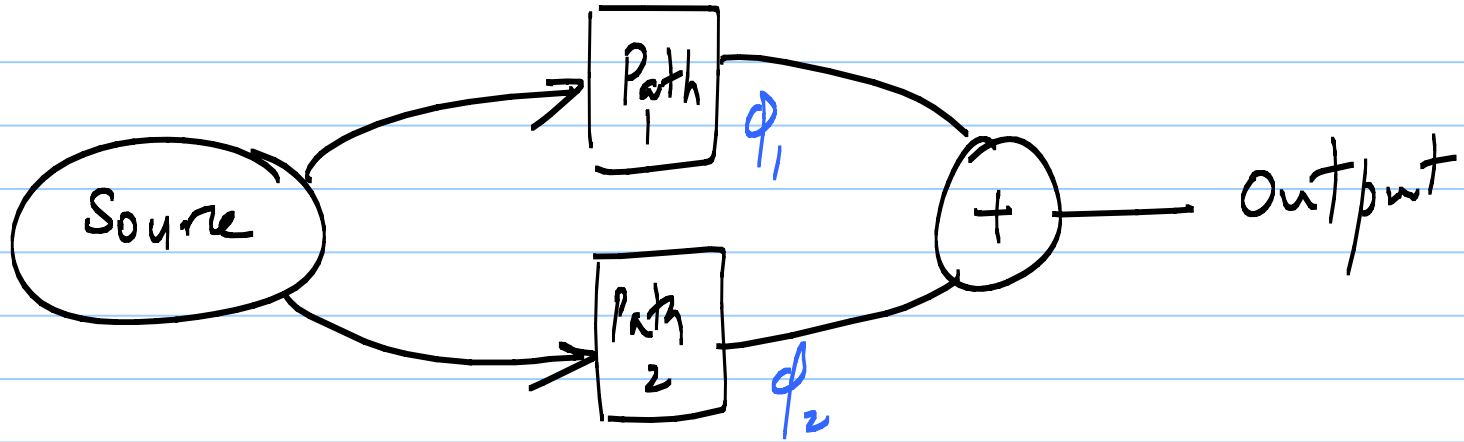
Order = # of capacitors − # of all-capacitor loops − # of capacitor-voltage source loops

= Degree of $D(s)$

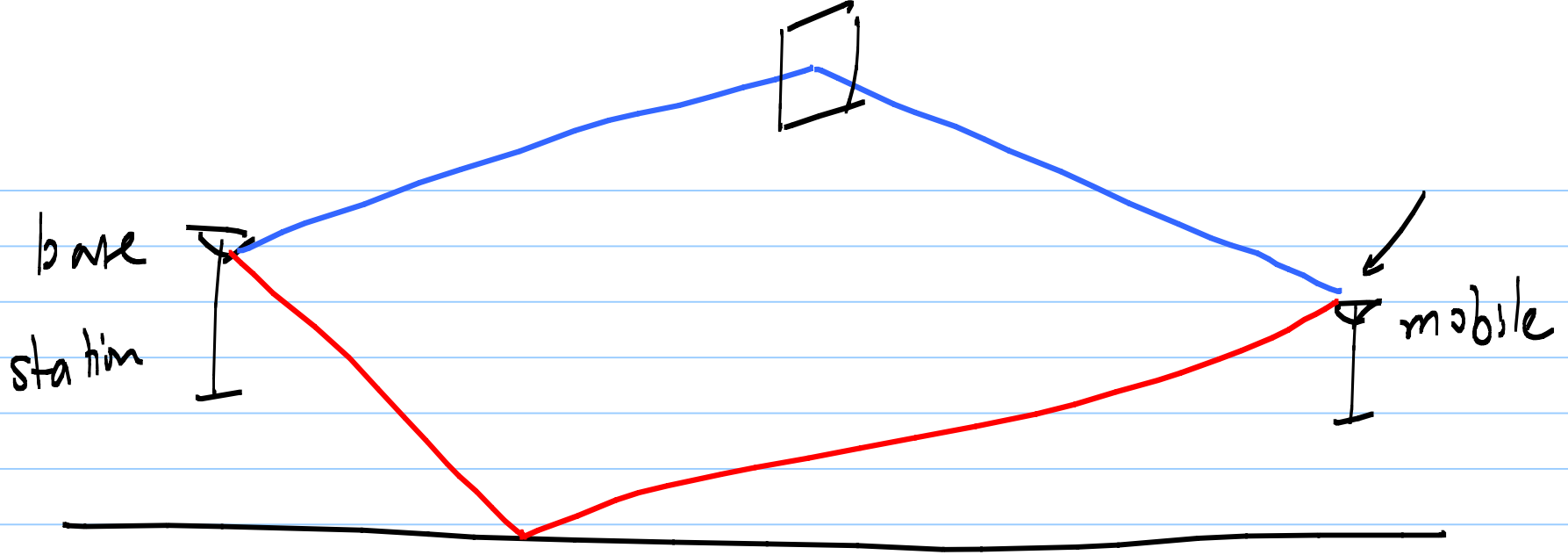
$N(s)$ degree = # of zeros

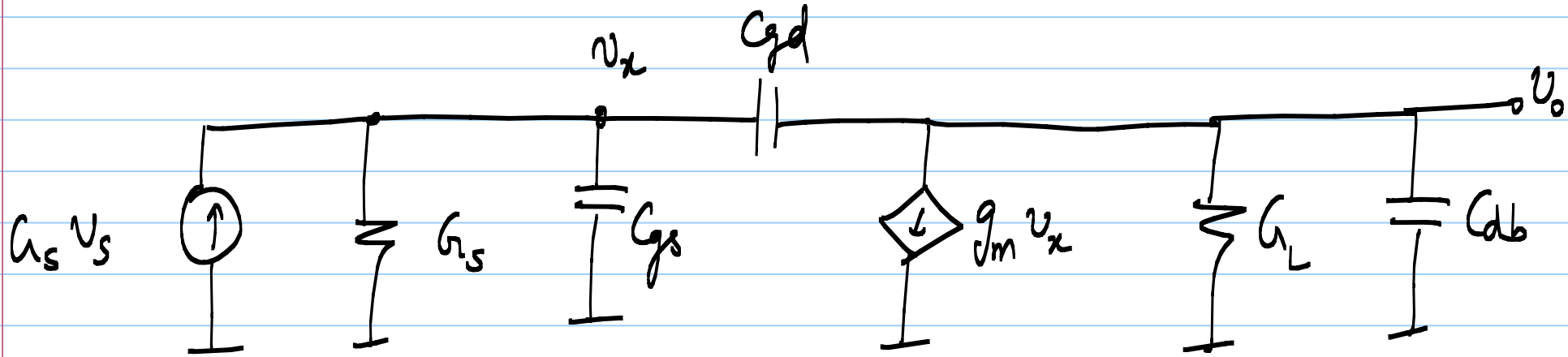
$$\frac{v_o}{v_s}(s) = \frac{N(s)}{D(s)}$$

@ zero frequency (s), $v_o(s) = 0$ independent of v_s



Zero ⇒ * multiple paths from input to output
and * phase shifts along paths are different





KCL @ input :

$$v_x s C_{gs} + v_x G_s + (v_x - v_o) s C_{gd} = v_s G_s$$

$$\Rightarrow \quad v_x \left[G_s + s(C_{gs} + C_{gd}) \right] = v_s G_s + v_o s C_{gd}$$

$$v_x = \frac{v_s G_s + v_o s C_{gd}}{G_s + s(C_{gs} + C_{gd})}$$

KCL @ output :

$$(v_o - v_x) s C_{gd} + v_o (G_L + s C_{db}) + g_m v_x = 0$$

HW $\rightarrow$ $\dfrac{v_o}{v_s}(s) = ?$

$$\frac{v_o}{v_s} = \underbrace{\text{(Low freq. gain)}}_{} \frac{\text{Zeroes } (N(s))}{\text{poles } (D(s))}$$

$$= \left(\frac{-g_m}{G_L}\right) \frac{1^{st} \text{ order } N(s)}{2^{nd} \text{ order } D(s)}$$