

EE-320 – Exercise 6 Solutions - Fall 2024

1

$$(a) A_V = -g_{m1} \left(\frac{1}{g_{m2}} || r_{o2} || r_{o1} \right) \Leftarrow \text{Common-source stage}$$

$$V_{out} = V_{DD} - |V_{GS2}| \quad \text{for } M_1 \text{ in saturation} \Rightarrow V_{GD} \leq V_{TH1}$$

$$\Rightarrow V_{in} - V_{out} \leq V_{TH1}$$

$$\Rightarrow V_{in,max} = V_{out} + V_{TH1} = V_{DD} - |V_{GS2}| + V_{TH1}$$

(b)

$$\text{if } V_{in} = V_{DD} \Rightarrow V_X = V_{DD} - V_{GS3}$$

$$M_1 \text{ in Sat} \Rightarrow V_X - V_{out} \leq V_{TH1}$$

$$V_{DD} - V_{GS3} - (V_{DD} - |V_{GS2}|) \leq V_{TH1}$$

$$|V_{GS2}| \leq V_{GS3} + V_{TH1}$$

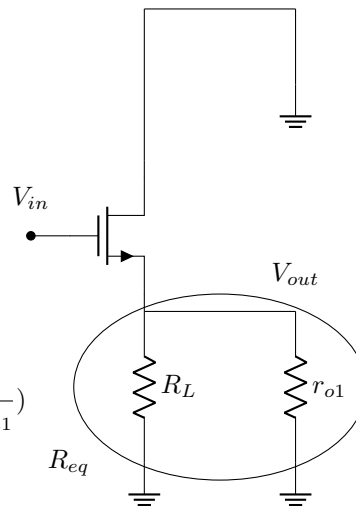
2

Gain of source follower:

(I_1 is open circuit in small signal)

$$A_v = \frac{V_{out}}{V_{in}} = \frac{R_{eq}}{R_{eq} + \frac{1}{g_{m1}}}$$

$$R_{eq} = R_L || r_{o1} = \frac{1}{g_{m1}} || r_{o1} \approx \frac{1}{g_{m1}} \text{ (since } r_{o1} \gg \frac{1}{g_{m1}} \text{)}$$



$$\begin{aligned}
\Rightarrow A_{V,SF} &= \frac{R_L}{R_L + \frac{1}{g_{m1}}} \\
&= \frac{g_{m1}R_L}{g_{m1}R_L + 1} \\
&= \frac{\frac{g_{m1}}{\frac{g_{m1}}{0.5} + 1}}{\frac{g_{m1}}{0.5}} = 0.5
\end{aligned}$$

Gain of CS stage: $A_v = \frac{V_{out}}{V_{in}}$

$$\begin{aligned}
&= -g_{m1}(R_L || r_{o1}) = -g_{m1}R_L \\
&= \frac{-g_{m1}}{-g_{m1}} = -1 \\
\Rightarrow \text{So } |A_{V,SF}| &< |A_{V,CS}|
\end{aligned}$$

