EE-320 – Exercise 6 Solutions - Fall 2025

1

$$
\begin{aligned}
&(a)\ A_V = -g_{m1}(\frac{1}{g_{m2}}||r_{o2}||r_{o1}) \Leftarrow \text{Common-source stage} \\
&\quad V_{out} = V_{DD} - |V_{GS2}| \qquad \text{for } M_1 \text{ in saturation } \Rightarrow V_{GD} \leqslant V_{TH1} \\
&\qquad \Rightarrow V_{in} - V_{out} \leqslant V_{TH1} \\
&\qquad \Rightarrow V_{in,max} = V_{out} + V_{TH1} = V_{DD} - |V_{GS2}| + V_{TH1}
\end{aligned}
$$

(b)

$$
\begin{aligned}
&\text{if } V_{in} = V_{DD} \Rightarrow V_X = V_{DD} - V_{GS3} \\
M_1 \text{ in Sat } &\Rightarrow V_X - V_{out} \leqslant V_{TH1} \\
&\qquad V_{DD} - V_{GS3} - (V_{DD} - |V_{GS2}|) \leqslant V_{TH1} \\
&\qquad |V_{GS2}| \leqslant V_{GS3} + V_{TH1}
\end{aligned}
$$

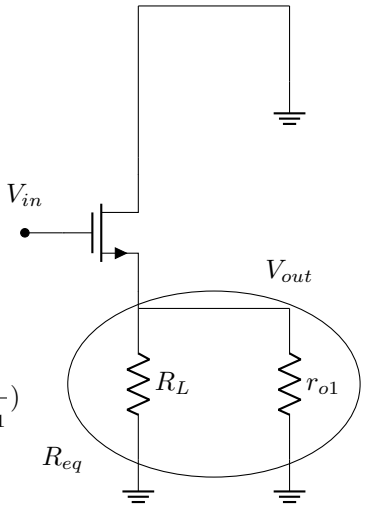
2

Gain of source follower:

(I_1 is open circuit in small signal)

$$A_v = \frac{V_{out}}{V_{in}} = \frac{R_{eq}}{R_{eq} + \frac{1}{gm_1}}$$

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



$$\Rightarrow A_{V,SF} = \frac{R_L}{R_L + \frac{1}{g_{m1}}}$$

$$= \frac{g_{m1}R_L}{g_{m1}R_L + 1}$$

$$= \frac{\frac{g_{m1}}{g_{m1}}}{\frac{g_{m1}}{g_{m1}} + 1} = 0.5$$

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

$$= -g_{m1}(R_L || r_{o1}) = -g_{m1}R_L$$

$$= \frac{-g_{m1}}{-g_{m1}} = -1$$

$\Rightarrow$ So $|AV_{SF}| < |AV_{CS}|$