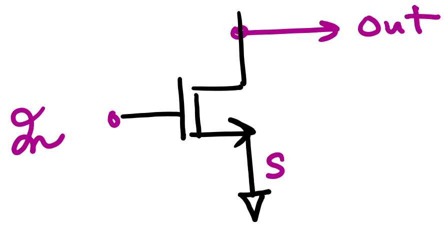
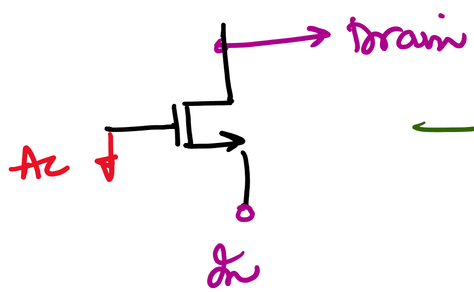
ECE 310 - Lecture 25

Monday, March 26, 2018 10:28 AM

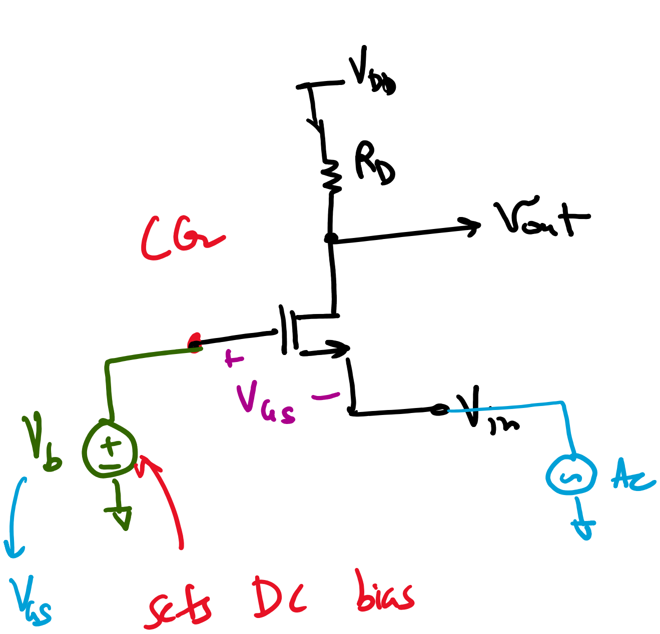
Common Source Amplifier

→ CS with source degeneration

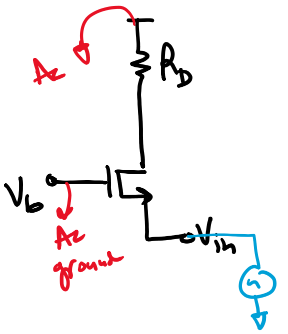


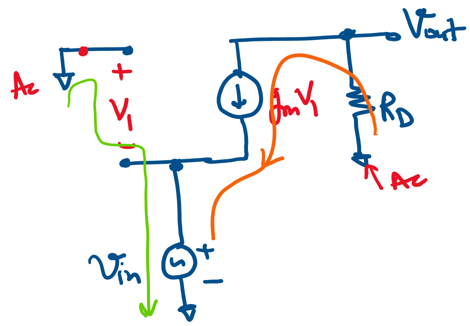


→ Common Gate amplifier



for the NMOS





$V_1 = V_{gs}$

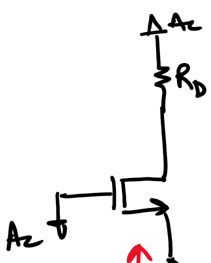
Here, $\lambda = 0$

KVL → $v_1 = -v_{in}$ → ①

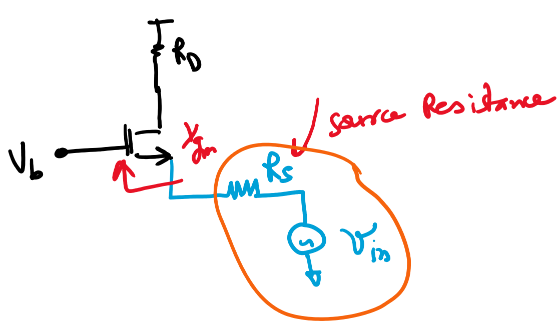
→ $v_{out} = -g_m V_1 \cdot R_D$ → ②

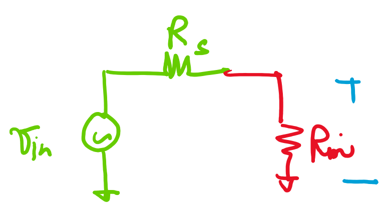
$\Rightarrow v_{out} = -g_m R_D(-v_{in}) = +g_m R_D v_{in}$

$\Rightarrow A_v = \frac{v_{out}}{v_{in}} = \boxed{+g_m R_D}$ → +ve gain non-inverting gain



$R_{in} \simeq 1/g_m \Leftarrow$ Small impedance, 100 Ω – kΩs



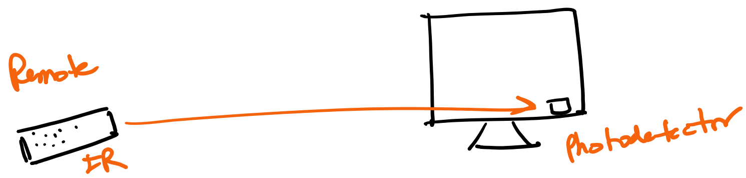


CS: $R_{in} \to \infty \Rightarrow$ No issue

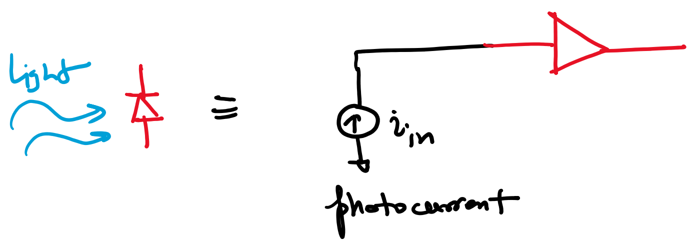
CG: $R_{in} \simeq 1/g_m \Rightarrow$ Voltage Divider

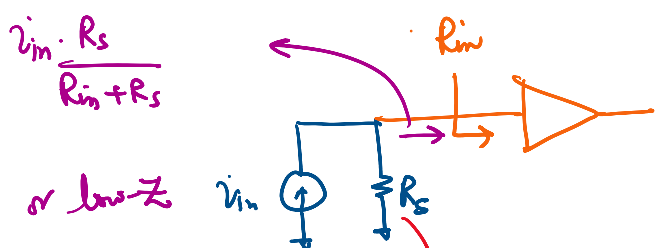
Not a great voltage amplifier

Not a great voltage amplifier due to low R_{in} :(



Current amplifier

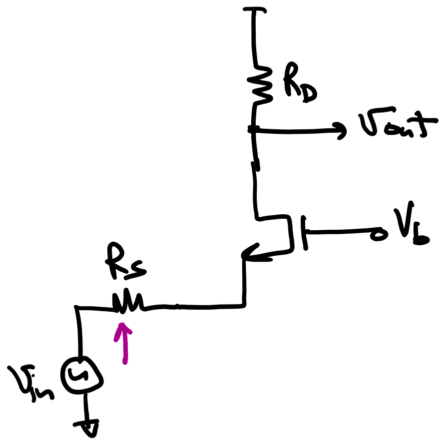




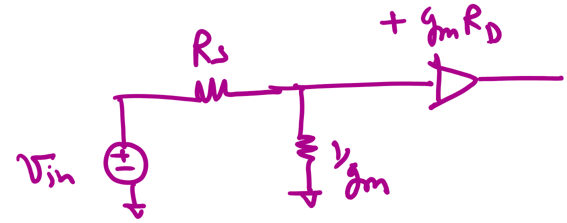
Norton Equiv Source Resistance

for $R_{in} = 0$ or low-Z most of the current flows into the current amplifier.

CG is Excellent for current amplifier applications!



⇒



$$\frac{v_{out}}{v_{in}} = \frac{g_m R_D \cdot \frac{1}{g_m}}{\frac{1}{g_m} + R_s} = \frac{R_D}{\frac{1}{g_m} + R_s}$$

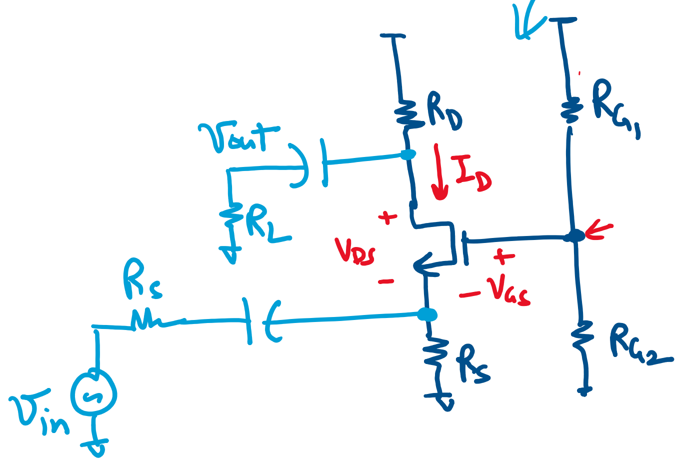
$$= +\frac{g_m R_D}{1 + g_m R_s}$$

Do Book Examples 17.22, 23, 24, 28, 34 & 35.

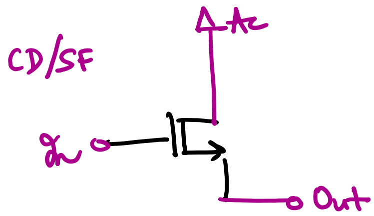
Ex. CG with biasing

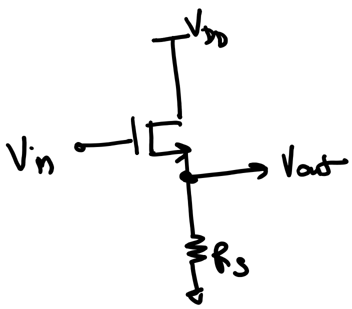
4-R Biasing

↳ Defines (V_{GS}, V_{DS}, I_D)



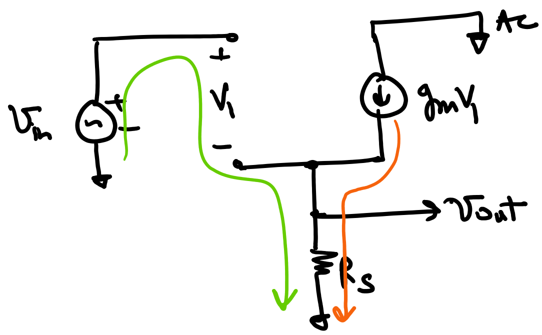
Common Drain ⇒ Source Follower (SF)





Small signal (AC) Equivalent Circuit

$\lambda = 0$



KVL: $V_1 = v_{in} - v_{out} \longrightarrow (1)$

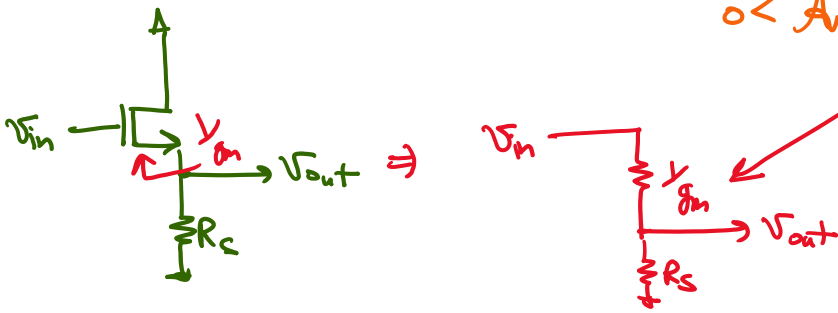
→ : $v_{out} = g_m V_1 \cdot R_s \longrightarrow (2)$

$\Rightarrow \quad v_{out} = g_m R_s \left[v_{in} - v_{out} \right]$

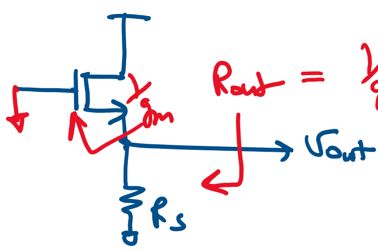
$\Rightarrow \quad v_{out}(1 + g_m R_s) = g_m R_s \, v_{in}$

$$\Rightarrow \quad A_v = \frac{v_{out}}{v_{in}} = \frac{g_m R_s}{1 + g_m R_s} = \boxed{\frac{R_s}{R_s + \frac{1}{g_m}}} \leq 1$$

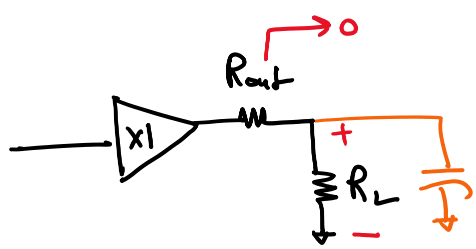
$0 < A_v < 1$:(



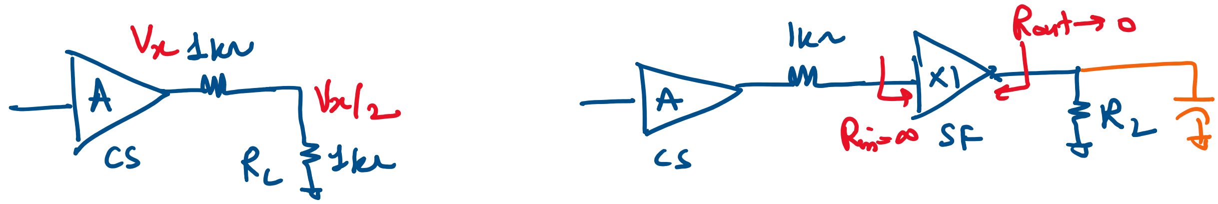
output impedance, $R_{out} = \frac{1}{g_m} \Rightarrow$ low impedance



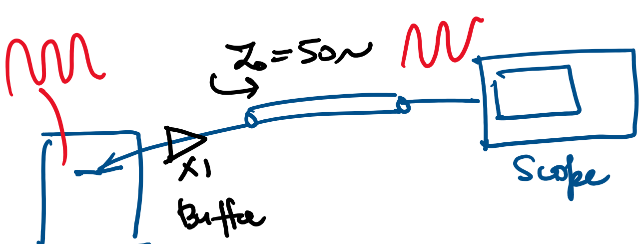
$$R_{out} = \frac{1}{g_m} \| R_s \simeq \frac{1}{g_m}$$

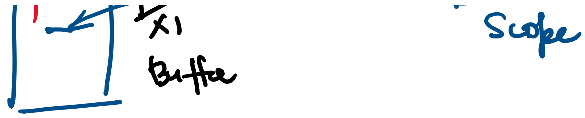


Voltage Buffer (VB)



VB is used to isolate load from a high gain amplifier

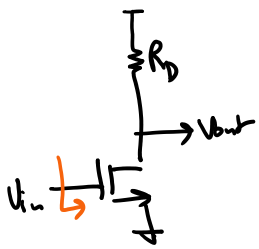




Excellant as a Voltage Buffer!

Summary of MOS Amplifier Stages (chapter 17)

CS



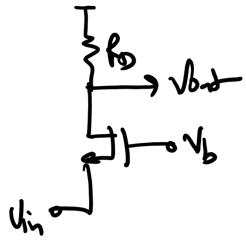
$A_v = -g_m(R_D \| r_o)$

$R_{in} \to \infty$

$R_{out} \simeq R_D \| r_o$

Voltage Amplifier

CG



$A_v = +g_m(R_D \| r_o)$

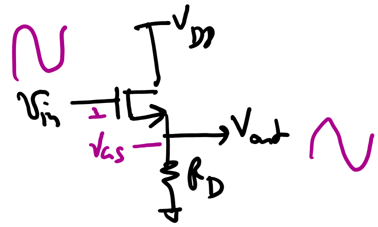
$R_{in} \simeq \frac{1}{g_m}$ (low)

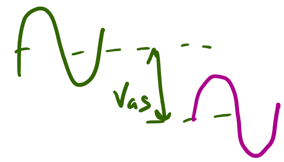
$R_{out} = R_D \| r_o$

Current Amplifier

" Buffer

CD / SF





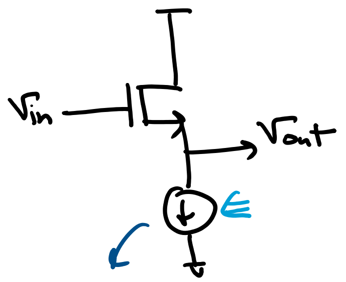
output follows the input

$A_v = \frac{R_D}{\frac{1}{g_m} + R_D}$

$R_{in} \to \infty$

$R_{out} \simeq \frac{1}{g_m} \to 0$ (low)

Voltage Buffer

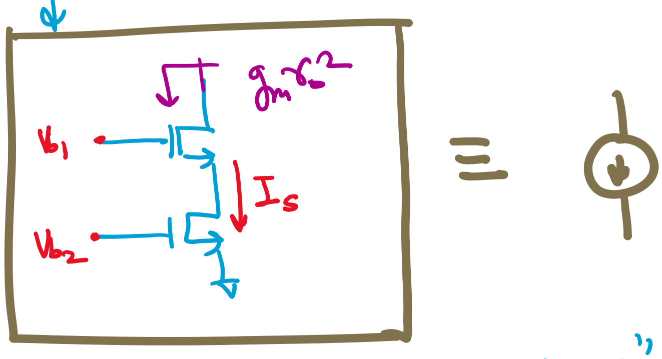


$$A_v = \frac{v_{out}}{v_{in}} = \frac{R_s}{R_s + 1/g_m} = \frac{1}{1 + \frac{1}{g_m R_s}} \approx 1$$

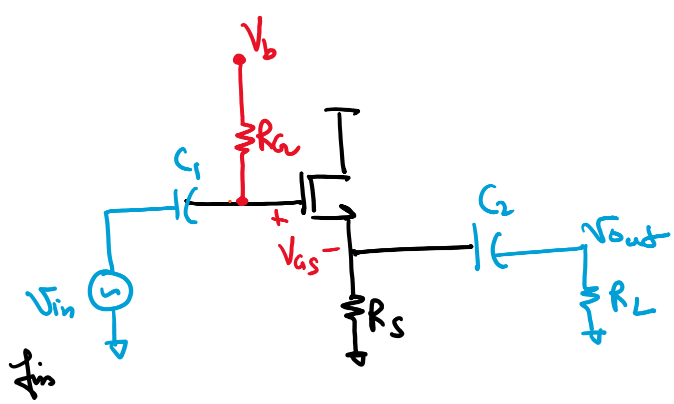
$R_s \to \infty$

Gain of 1

$R_s \Rightarrow$ output resistance of the current source (ideally ∞)



" Cascode Current Mirror "



$$\tau = R_G C_1 > \frac{10}{f_{in}}$$