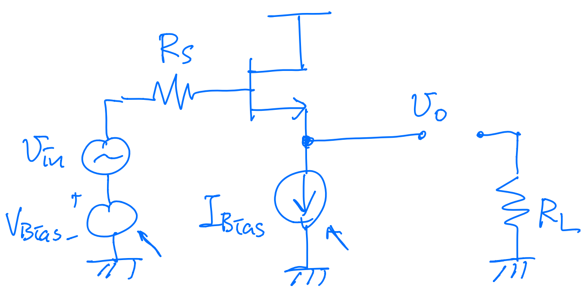
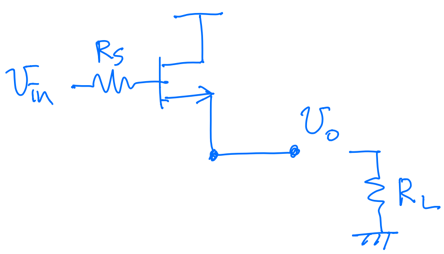
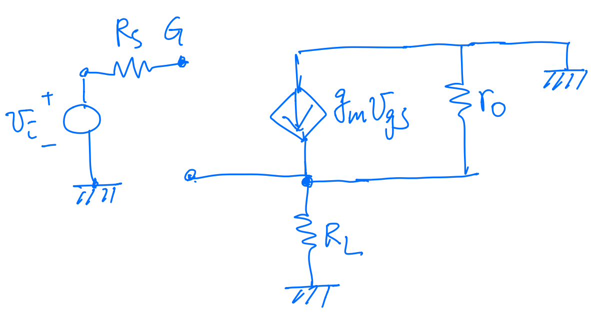
Common Source (CS)
Common Gate (CG)
Common Drain (CD)

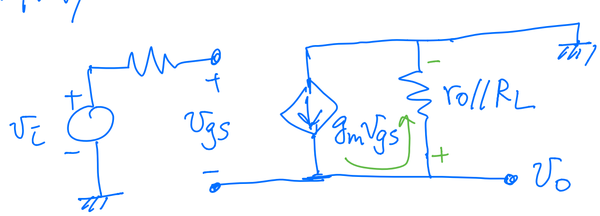


AC





Simplify



$$v_{gs} = v_i$$

$$v_o = g_m v_{gs} (r_o // R_L) = g_m (v_i - v_o)(r_o // R_L)$$

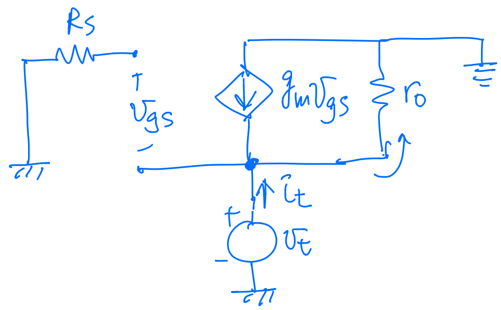
$$\frac{v_o}{v_i} = \frac{g_m (r_o // R_L)}{1 + g_m (r_o // R_L)} \approx 1$$

$$g_m r_o \gg 1$$

$$g_m (r_o // R_L) \gg 1$$

$R_{in} = \infty$

R_{out}



$v_{gs} = 0 - v_t = -v_t$

KCL at source $\quad i_t + g_m v_{gs} = \frac{v_t}{r_o}$

$$i_t - g_m v_t = \frac{v_t}{r_o}$$

$$R_{out} = \frac{v_t}{i_t} = \frac{1}{\frac{1}{r_o} + g_m} \approx \frac{1}{g_m}$$

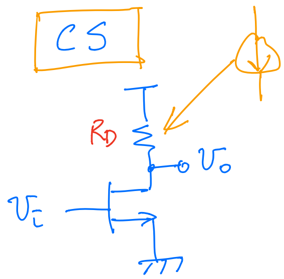
Previously

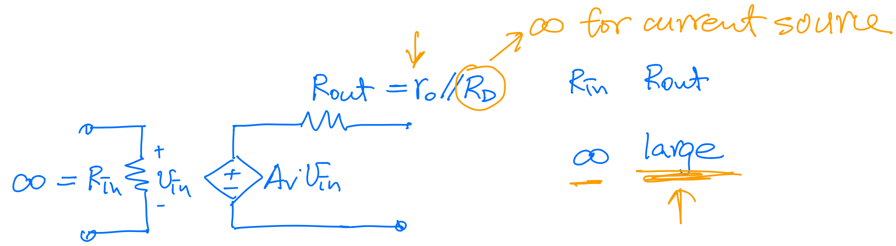
$r_o \sim 100\,k\Omega$ large

$g_m \sim mS$

$\frac{1}{g_m} \sim k\Omega$ small

CS

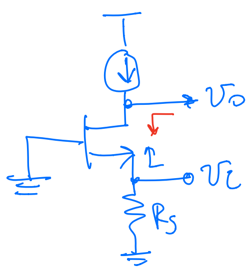


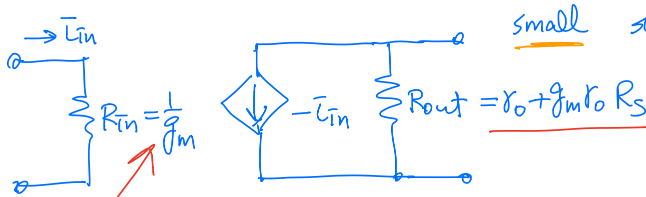


voltage amplifier

R_{in}	R_{out}
∞	large

CG

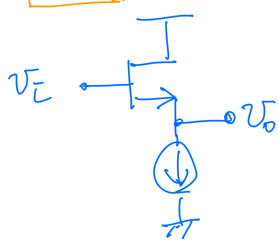


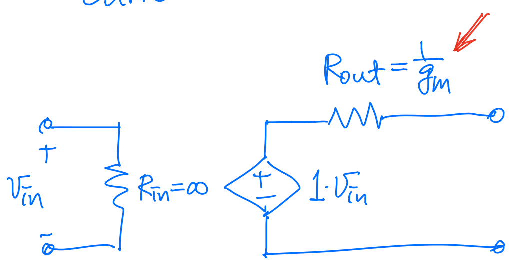


Current buffer

R_{in}	R_{out}
small	super large

CD

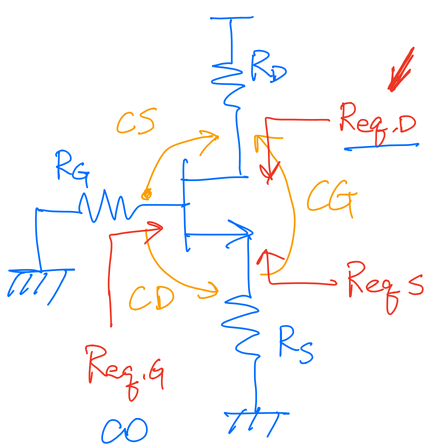


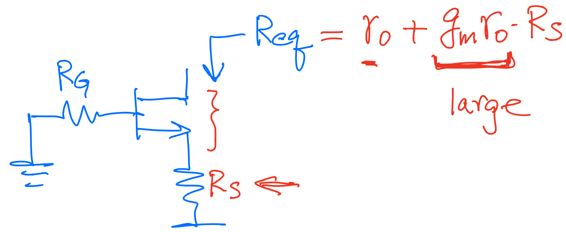


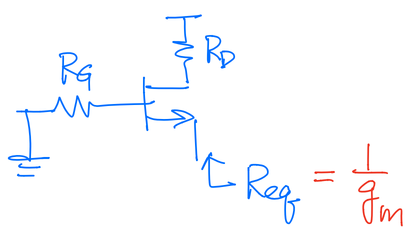
Voltage Buffer

R_{in}	R_{out}
∞	small

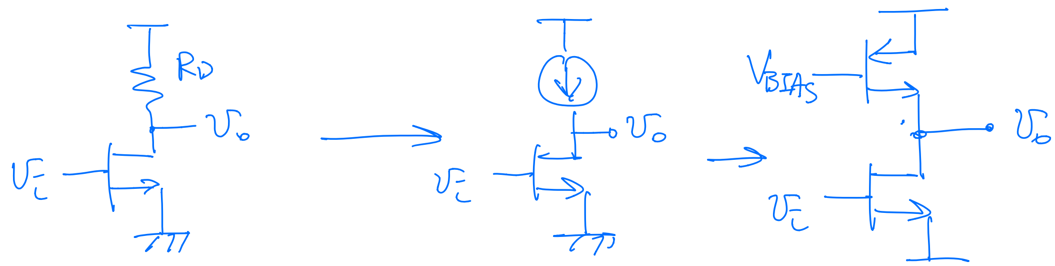
Consider Generally loaded FET







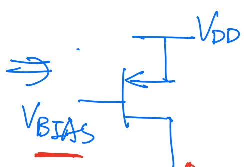
Current Mirrors



A_v: $-g_m(r_o // R_D)$ $\approx -g_m R_D$ | $-g_m r_o$ ↑

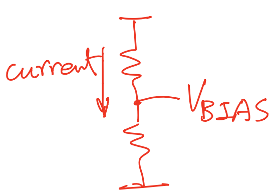
R_{out}: $r_o // R_D \approx R_D$ | r_o ↑

What is (↓) ?



$R_{eq} = r_o$

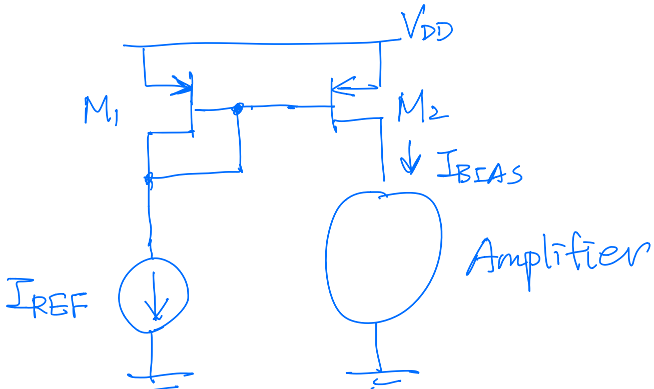
$$I_{BIAS} = I_{D,PMOS} = \frac{1}{2} k_p \left[(V_{DD} - V_{BIAS}) - |V_{t,p}| \right]^2$$



undesirable

① Power consumption
② IC, Resistor → transistor

Current Mirror



M_1: "Diode connection"
G — D
⇒ M_1 always in Sat.
$V_{G_1} = V_{D_1}$

$$I_{REF} = \frac{k_p}{2} \left[(V_{DD} - V_{G_1}) - |V_{tp}| \right]^2$$

M_2: Biased with $V_{G_2} = V_{G_1}$

If M_1 and M_2 are same transitors,

$$I_{BIAS} = I_{REF}$$

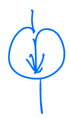
How do we obtain different current?

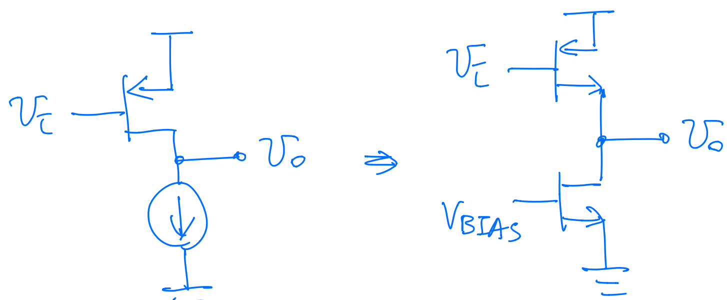
$$I_D = \frac{1}{2} k_p' \left(\frac{W}{L}\right) (V_{ov})^2$$

$k_p' = \mu_p C_{ox}$

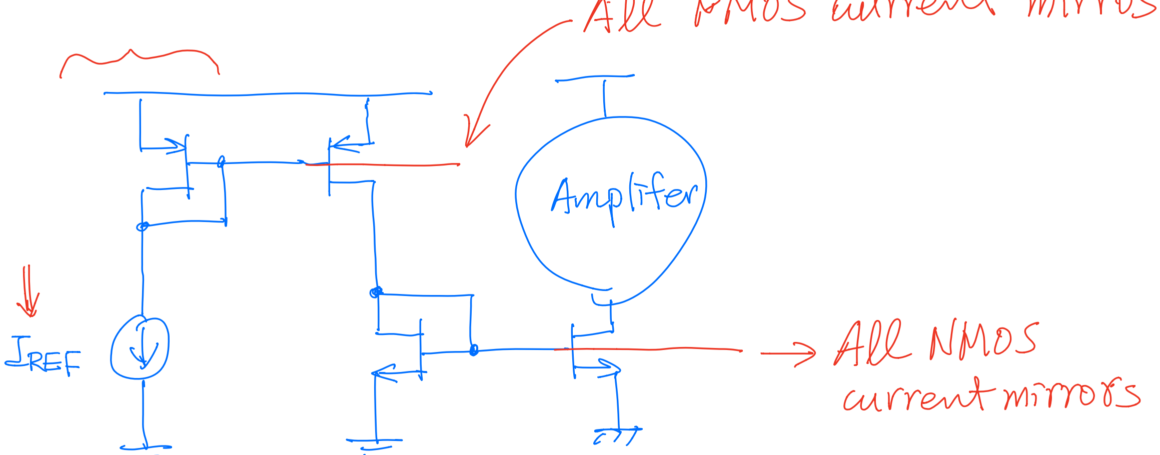
Vary $\left(\frac{W}{L}\right)$ of M_2

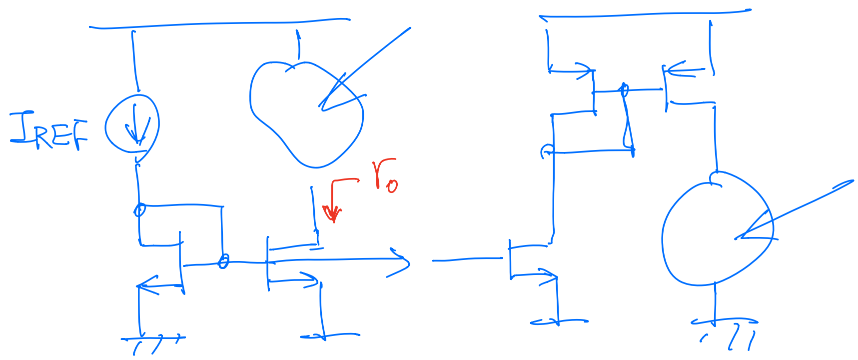
$$I_{BIAS} = I_{REF} \frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1}$$

Need 

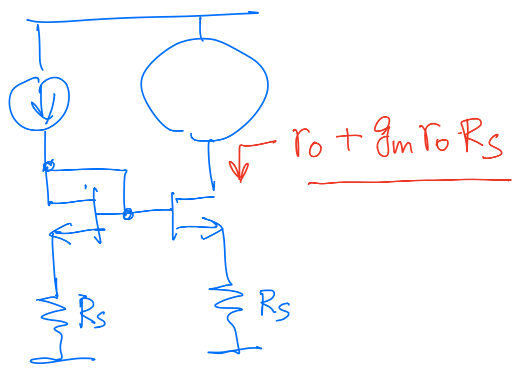


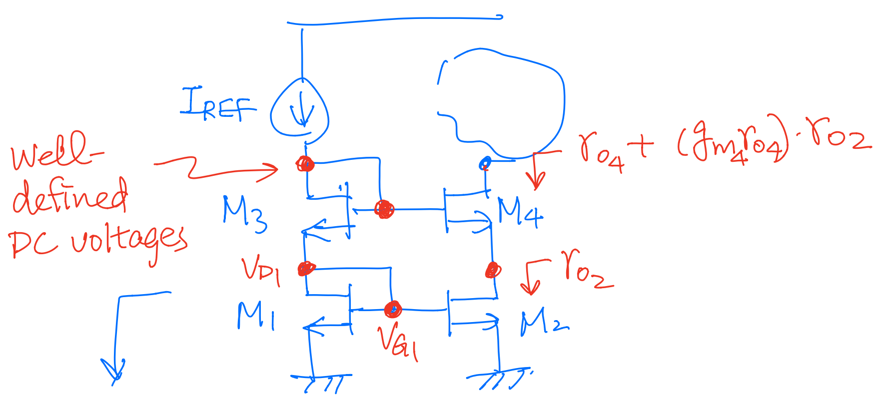
CS in PMOS





Super large Equivalent resistance





Disadvantage: Output swing smaller

Both M_2 and M_4 need to be kept at Saturation

What is V_{OUT} minimum?

$V_{out,min} = V_{G4} - V_{t,n} = V_{ov,4}$

$= V_{G3} - V_{tn}$

$= V_{ov_1} + V_{ov_3} + V_{t,n}$

$V_{G1} = V_{D1}$

$V_{G3} = V_{D3}$

$I_{REF} = \frac{1}{2} k_n V_{ov_i}^2 \Rightarrow$ know $V_{ov_1} = V_{GS_1} - V_{tn} \Rightarrow V_{G_1}$

$V_{ov_3} = V_{GS_3} - V_{t,n} \Rightarrow V_{GS3}$

$V_{G3} = V_{S3} + V_{ov_3} + V_{tn}$

$= V_{G_1} + V_{ov_3} + V_{tn}$ (V_{ov_1})

$= V_{ov_1} + V_{tn} + V_{ov_3} + V_{tn}$