Lec 3: MOS and Bipolar Cascade Amp.

• **Cascode Amp**

Ideal

V_{in} —| $g_m V_{in}$ —• V_{out}

$A_v = -g_m r_o$

V_{out}

M_1

M_2

(a)

I_{out}
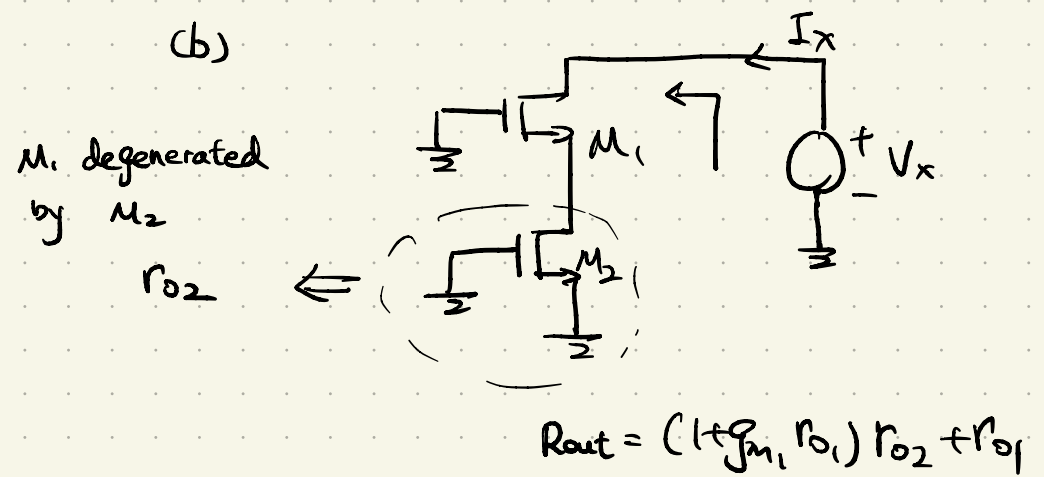
M_1

$g_{m2} V_{in}$ r_{o2}

V_{in} —| M_2

$I_{out} \cong g_{m2} V_{in}$

$\Rightarrow G_m = g_{m2}$

(b)

M_1 degenerated by M_2

$r_{o2} \Leftarrow$

M_1

M_2

I_x

$\overset{+}{\underset{-}{V_x}}$
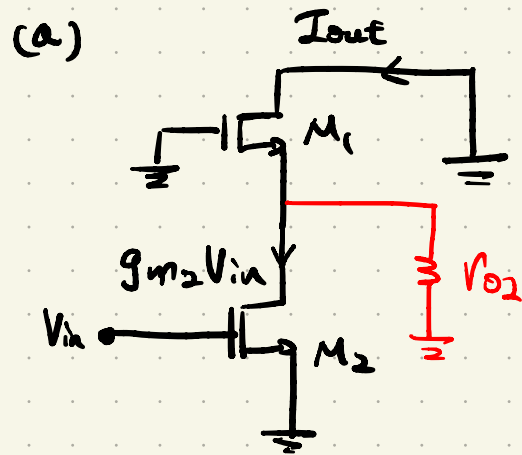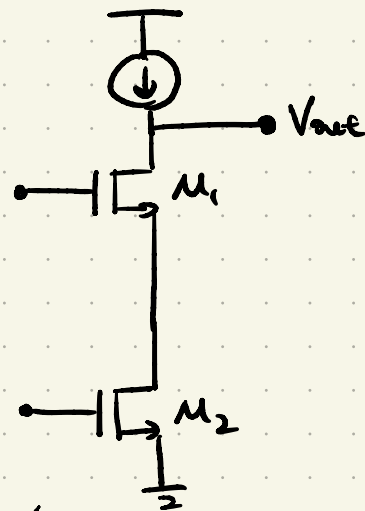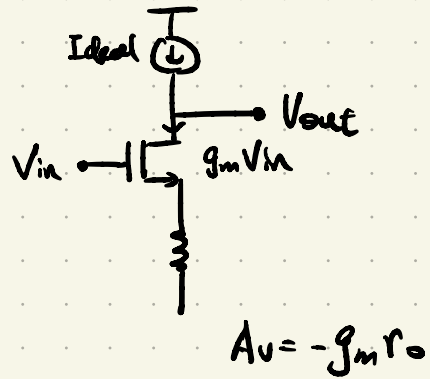
$R_{out} = (1 + g_{m_1} r_{o_1}) r_{o_2} + r_{o_1}$

$$A_v = -g_{m_2} \left[(1 + g_{m_1} r_{o_1}) r_{o_2} + r_{o_1} \right]$$

$$\approx -g_{m_1} r_{o_1} g_{m_2} r_{o_2}$$

Q:

R_x ?
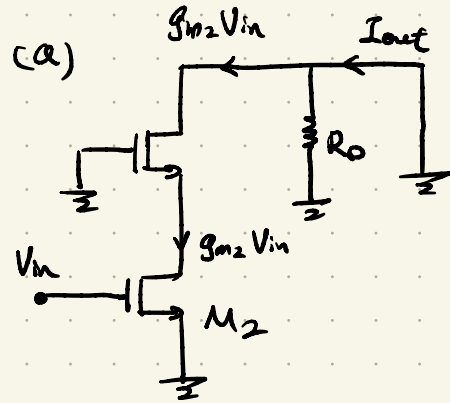
$+$

r_o

V_t
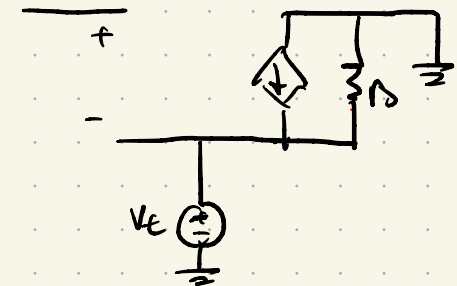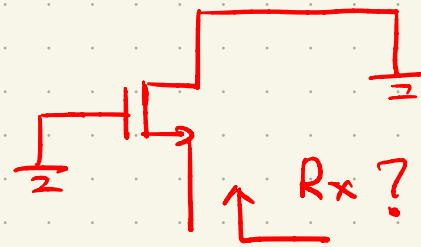
$$A: \quad R_x = \frac{r_o}{1 + g_m r_o} \quad \text{or} \quad \frac{1}{g_{m1}} \parallel r_{o1}$$
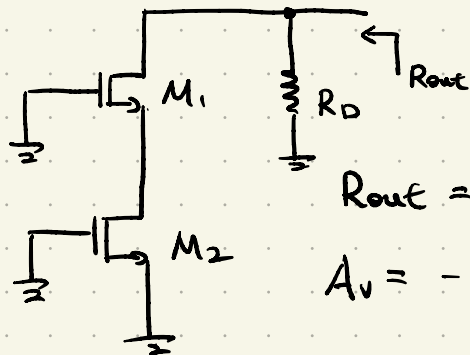
Example:

$A_v = ?$

(a)
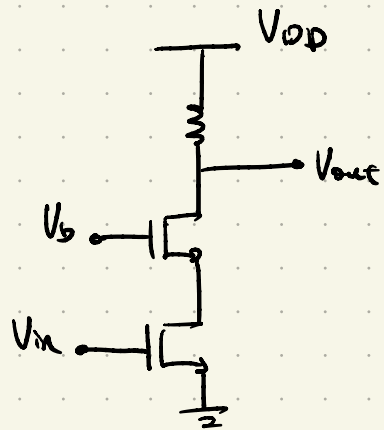
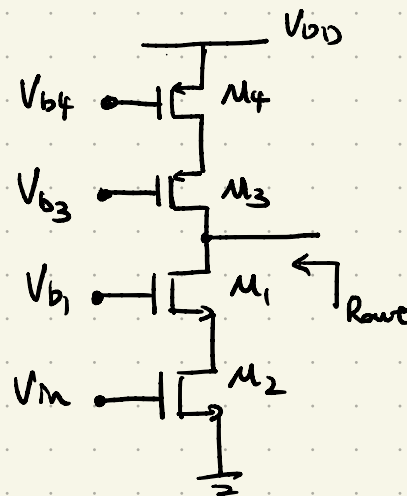$G_m = \dfrac{I_{out}}{V_{in}} = \dfrac{g_{m_2} V_{in}}{V_{in}} = g_{m_2}$

(b)

$R_{out} = R_D \| \left[(1 + g_{m_1} r_{o_1}) r_{o_2} + r_{o_1} \right]$

$A_v = -g_{m_2} R_D \| \left[(1 + g_{m_1} r_{o_1}) r_{o_2} + r_{o_1} \right]$

this R_D is BAD :(

• Cascode Amp with current source Load

$A_v = -g_{m_2} \left\{ r_{o_3} \| \left[1 + g_{m_1} r_{o_1} \right] r_{o_2} + r_{o_1} \right\}$
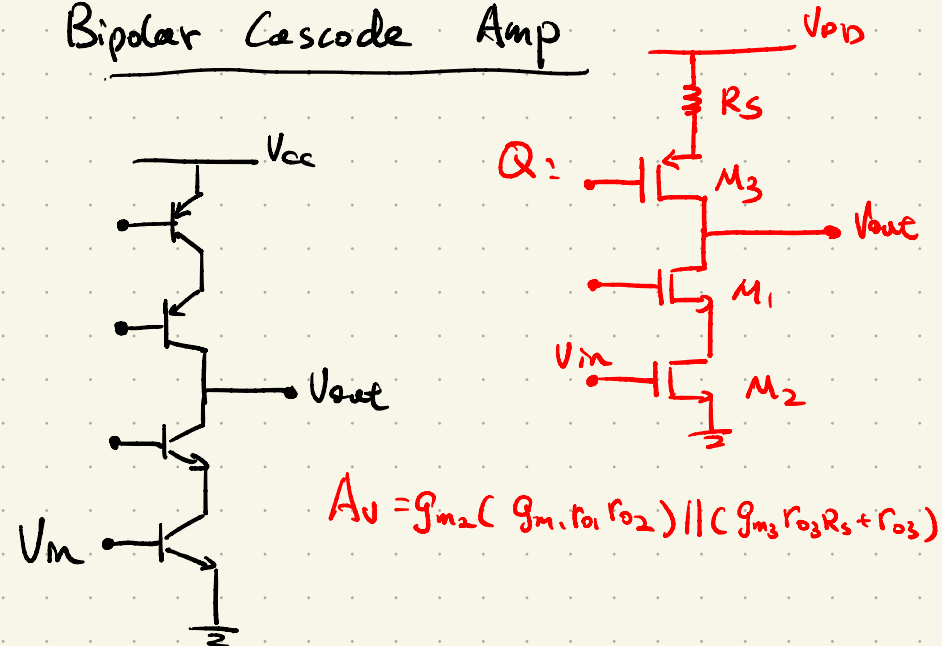

Cascode Amp with Cascode Load

(a) $G_m = g_{m_2}$

(b) $R_{out} = ?$

$R_{out} = \left\{ (1 + g_{m_1} r_{o_1}) r_{o_2} + r_{o_1} \right\} \| \left\{ (1 + g_{m_3} r_{o_3}) r_{o_4} + r_{o_3} \right\}$
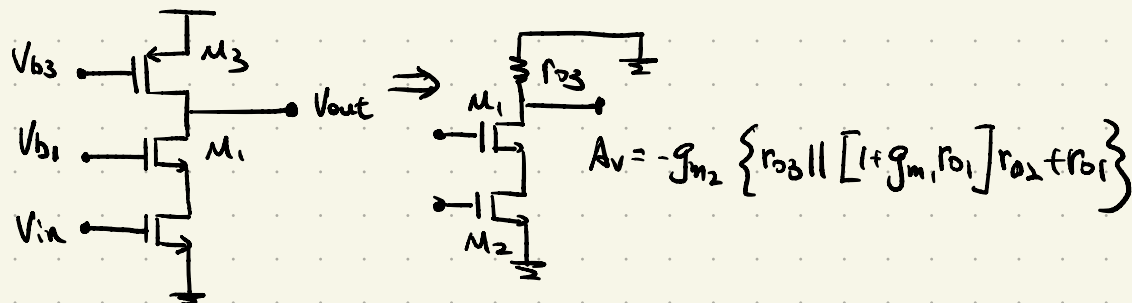
A_v: tens to hundreds

Bipolar Cascode Amp

$A_v = g_{m_2} (g_{m_1} r_{o_1} r_{o_2}) \| (g_{m_3} r_{o_3} R_s + r_{o_3})$