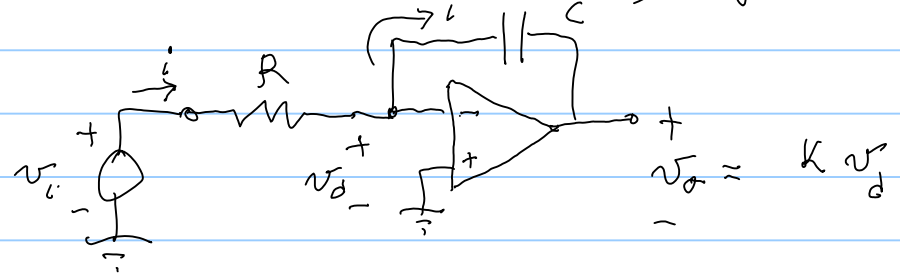
EE 303H
10/06/15

Note Title 10/6/2015

OTA = operational transconductance amplifier } $i_{in} = 0$
v_{in} & i_{out} = VCCS

op-amp has v_{in} & v_{out}, large A_v



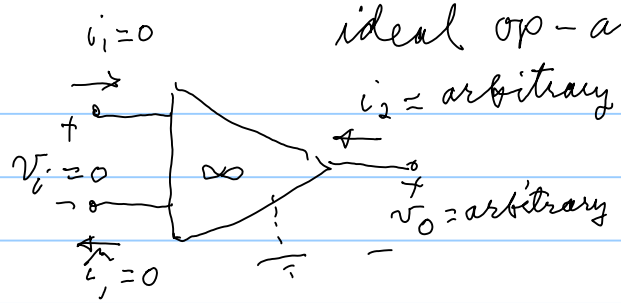
$$i = G(v_i - v_d) = sC(v_d - v_o) \Rightarrow v_i = v_d + \frac{sC}{G} v_d - \frac{sC}{G} v_o$$

$$(1 + sRC) v_d = v_i + sRC\, v_o \Rightarrow v_o = \frac{K(v_i + sRC\, v_o)}{1 + sRC}$$

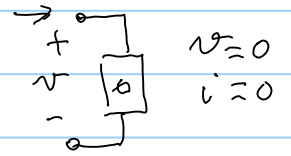
$$(1 + sRC) v_o - K sRC\, v_o = K v_i$$

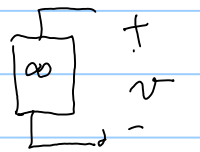
$$\frac{v_o}{v_i} = A_v = \frac{K}{-KsRC + (1 + sRC)}$$

if $K \to \infty$ $= \frac{K}{K} \cdot \frac{-1}{sRC} = -\frac{1}{sRC} = A_v \Rightarrow$ integrator

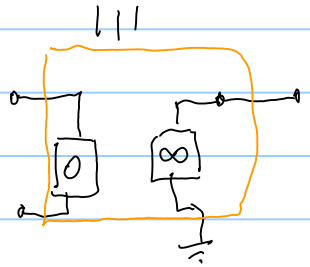


ideal op-amp

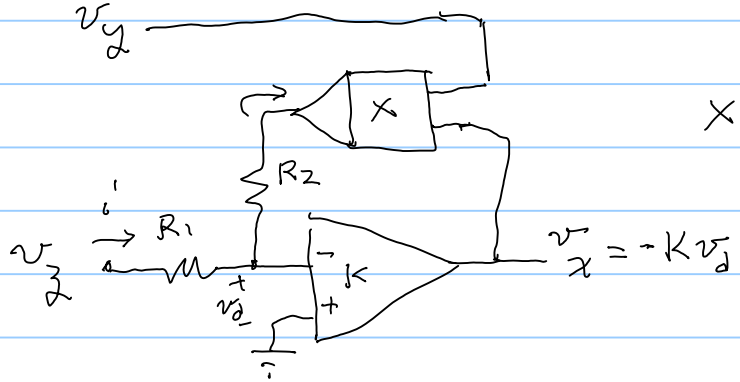




v & i arbitrary



Getting $1/x$



$X \Rightarrow v_{out} = k \cdot v_y \cdot v_x$

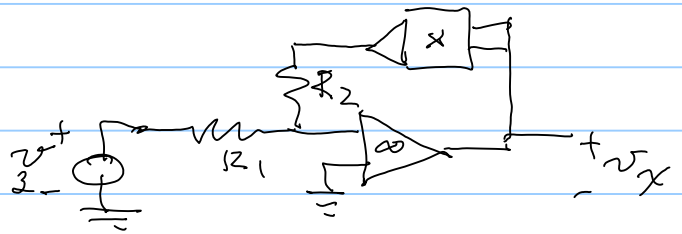
$$i = G_1(v_d - v_2) = G_2(v_d - k v_y v_x) \Rightarrow (G_1 - G_2)v_d = G_1 v_2 - G_2 k v_y v_x$$

$$v_d = G_1 v_2 - G_2 k v_y (-K v_d) \Rightarrow (1 - kK G_2 v_y) v_d = G_1 v_2$$

$$v_x = \frac{-K G_1}{1 - kK G_2 v_y} \cdot v_2 \xrightarrow[K \to \infty]{} v_x = \frac{G_1}{kG_2} \cdot \frac{v_2}{v_y}$$

gives an output v_x which divides an input v_2 by the v_y

if connect $v_y = v_x$



$$v_x^2 = \frac{G_1}{kG_2} \cdot v_2$$

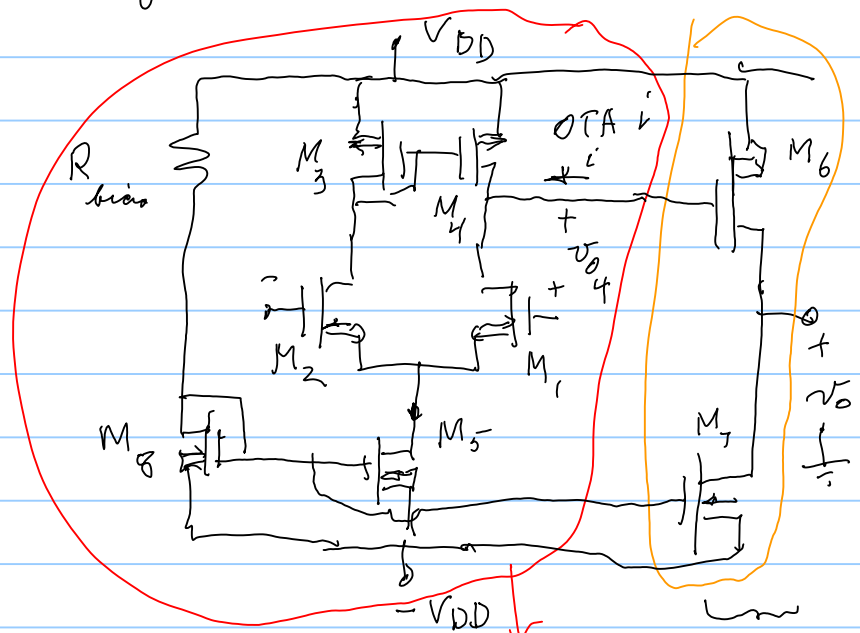
$$\Rightarrow v_x = \pm \sqrt{\frac{G_1}{kG_2} \cdot v_2}$$

assumes $v_2 > 0$ if $k > 0$
or $v_2 < 0$ if $k < 0$

(becomes unstable if $v_2/k < 0$)

MOS op amps Ed 6 Chap. 8.6.1 p. 652 also Sec. 12.1 p. 967
Ed 7 Chap. 9.6, p. 660 " " 13.1.1 p. 997

circuit for MOS op-amp

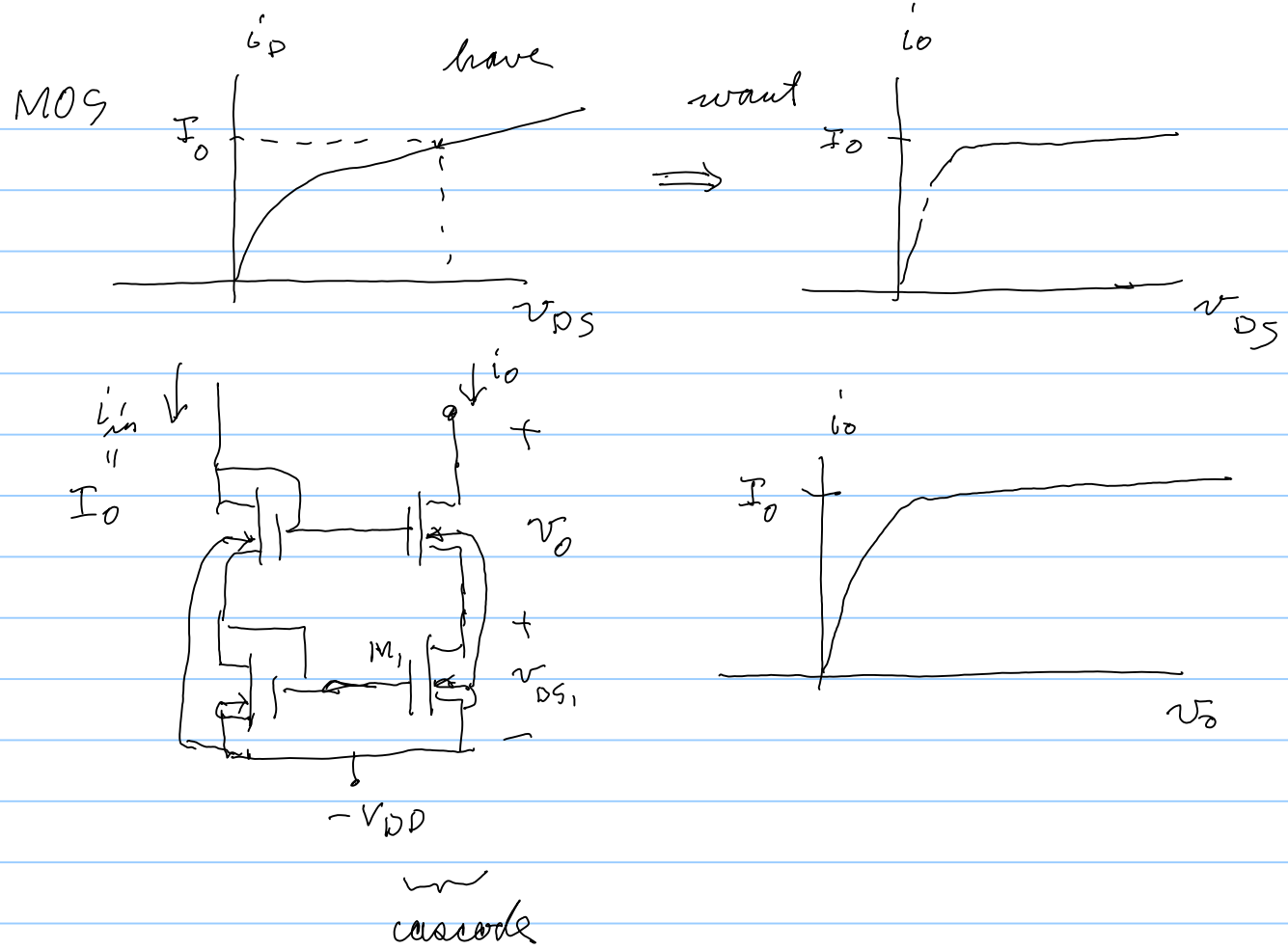


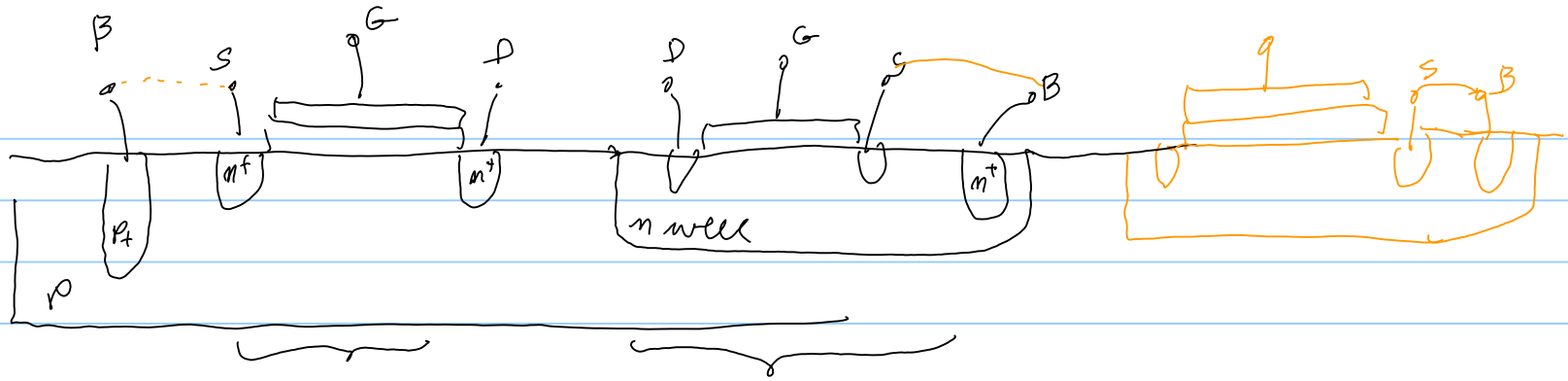
$$A_v = \frac{v_o}{v_i} = \frac{v_o}{v_{o4}} \times \frac{v_{o4}}{v_i} = g_{m_1} g_{m_6} (r_{o6} \| r_{o7})(r_{o4} \| r_{o1})$$

$$A_{v_2} \quad A_{v_1}$$

$$A_{v_2} = -g_{m_6} \times (r_{o6} \| r_{o7})$$

$$A_{v_1} = -g_{m_1} (r_{o4} \| r_{o1})$$


MOS
i_D
have
I_O
v_{DS}
want
i_o
I_O
v_{DS}
i_{in}
I_O
i_o
+
v_O
+
M_1
v_{DS_1}
−
$-V_{DD}$
cascode
i_o
I_O
v_O



n mos

p mos

all bulks the same (= the wafer)