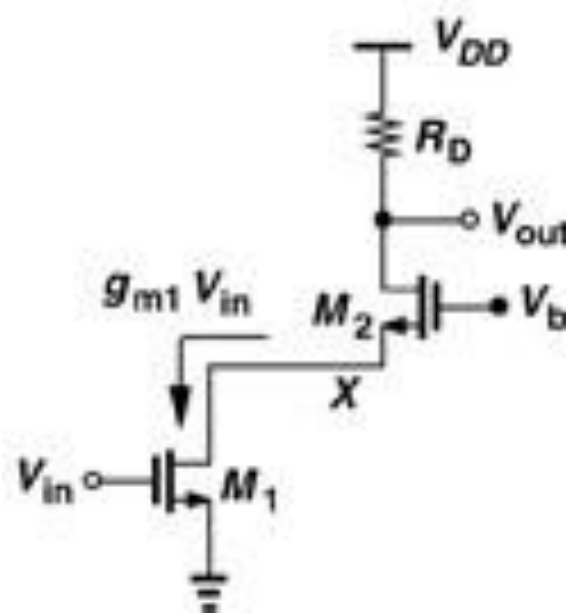
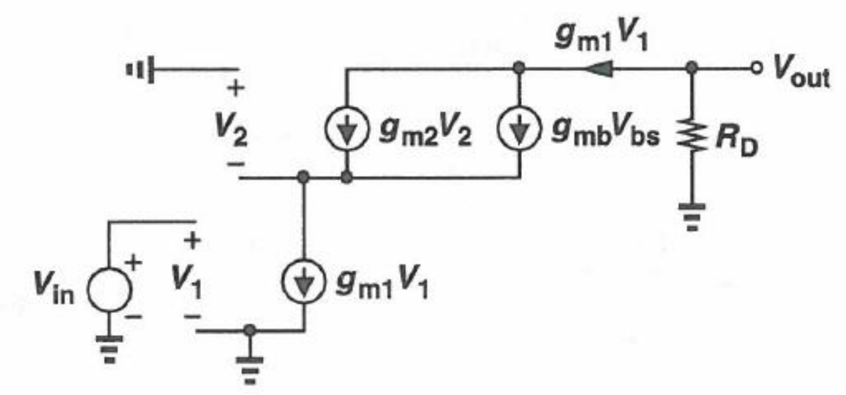
Lecture 3
IL2218 Analog electronics, advanced course

- Chapter 3 Cascode amplifiers
- Chapter 4 Differential amplifiers
- Examples

Cascode amplifier

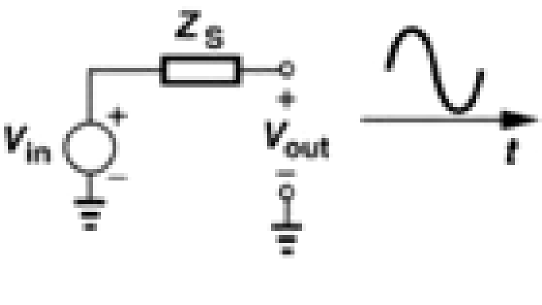


Small signal model

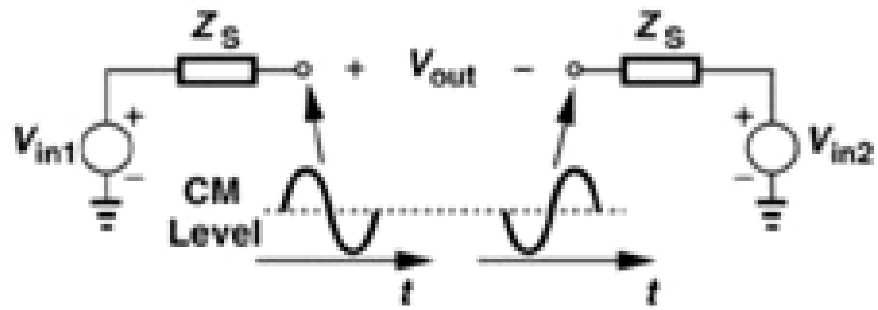


Differential amplifier
Why differential?

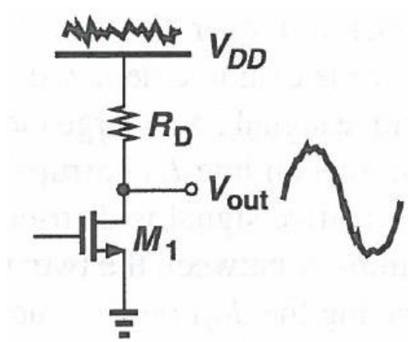
Single ended output



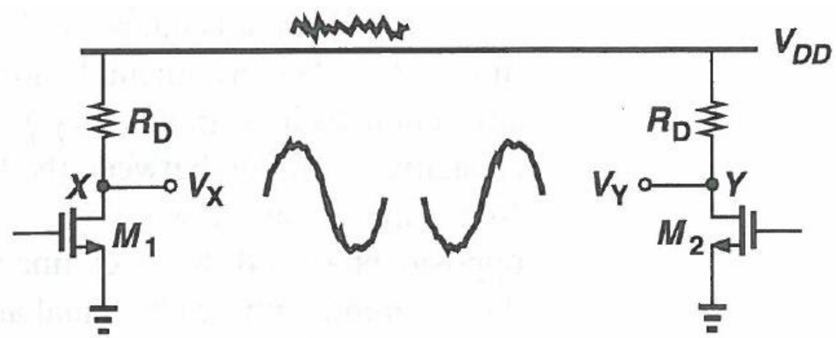
Differential output



Noisy V_{DD}

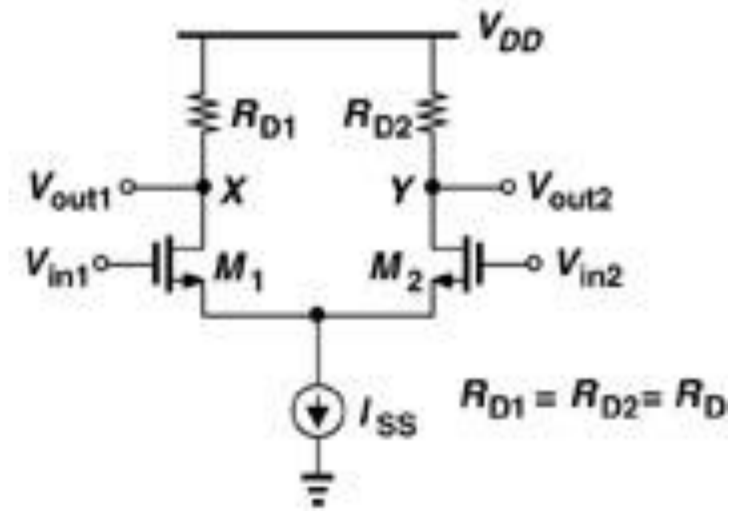


Noise reduction



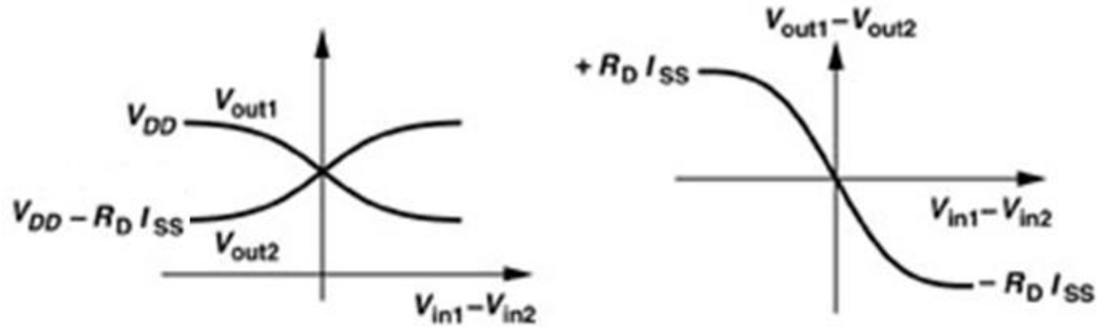
What is wrong in this picture?

Basic differential pair



Constant tail current I_{SS}
We can increase the current at one side if it is decreased at the other side $I_{D1} = -I_{D2}$

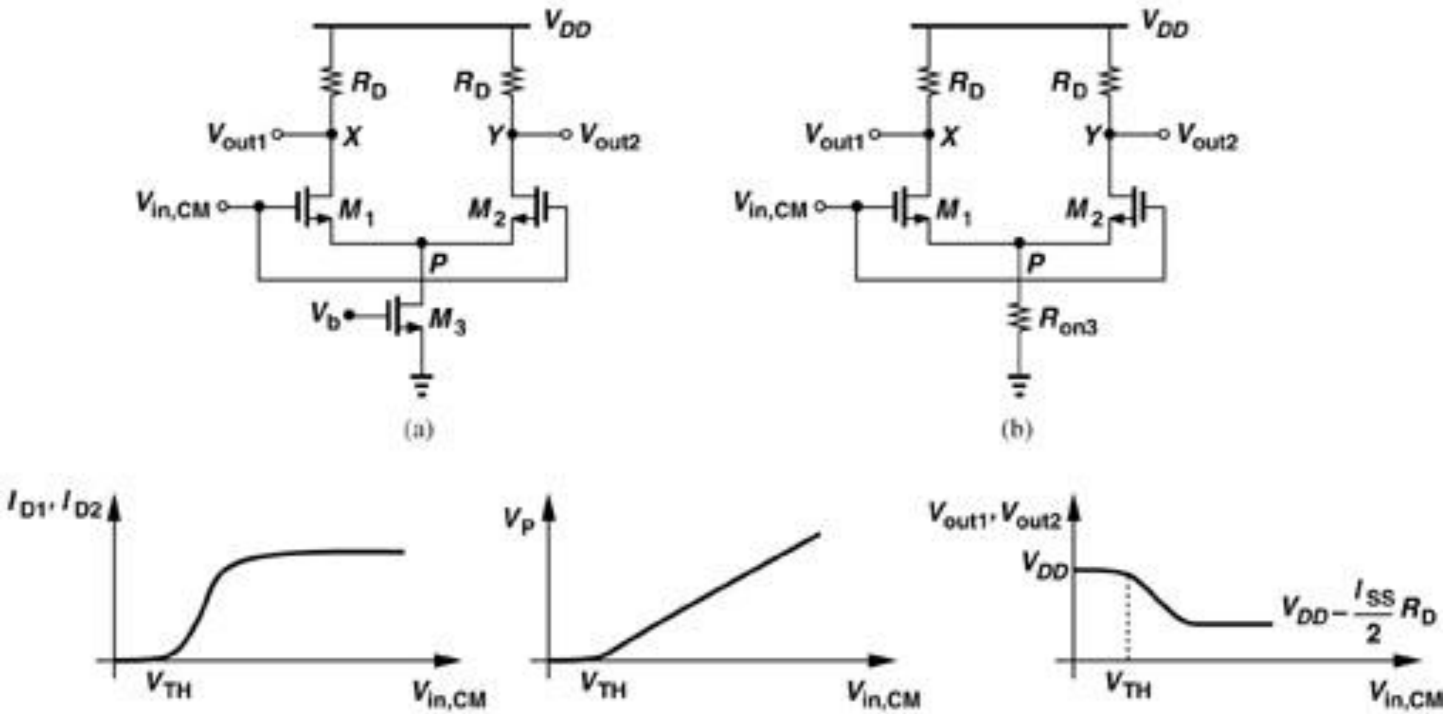
What will happen if $V_{in1} = V_{in2}$ and the input voltage is increasing?



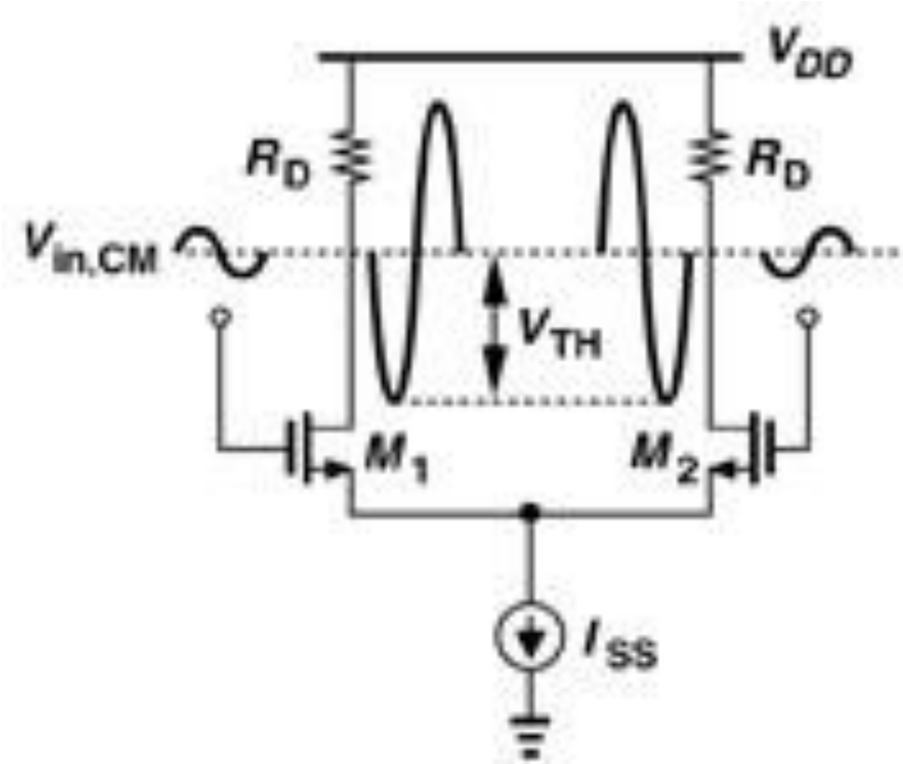
Input-output characteristics of a differential pair

Common mode response

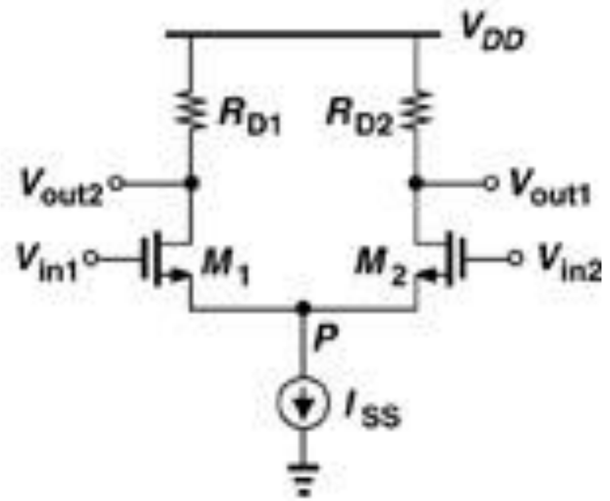
Tail current source with finite output resistance



Common mode, output sving



Differential gain



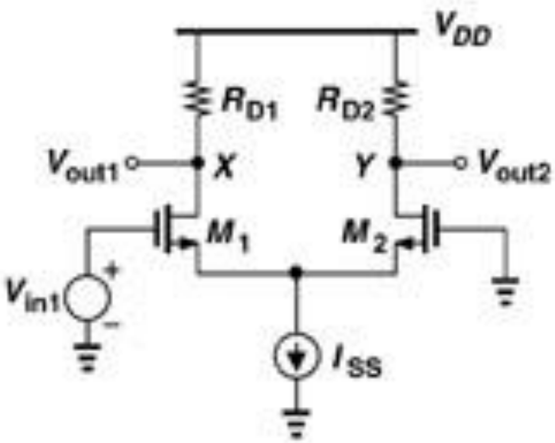
Differential gain

$$A_v = \frac{V_{out1} - V_{out2}}{V_{in1} - V_{in2}} = g_m R_D$$

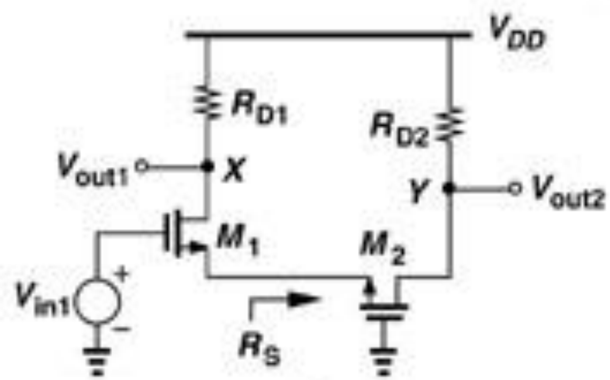
Single ended output

$$A_v = \frac{g_m}{2} R_D$$

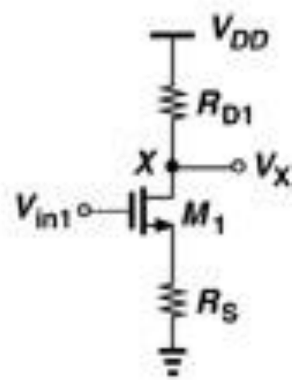
Differential mode gain



(a)



(b)



(c)

Single ended output

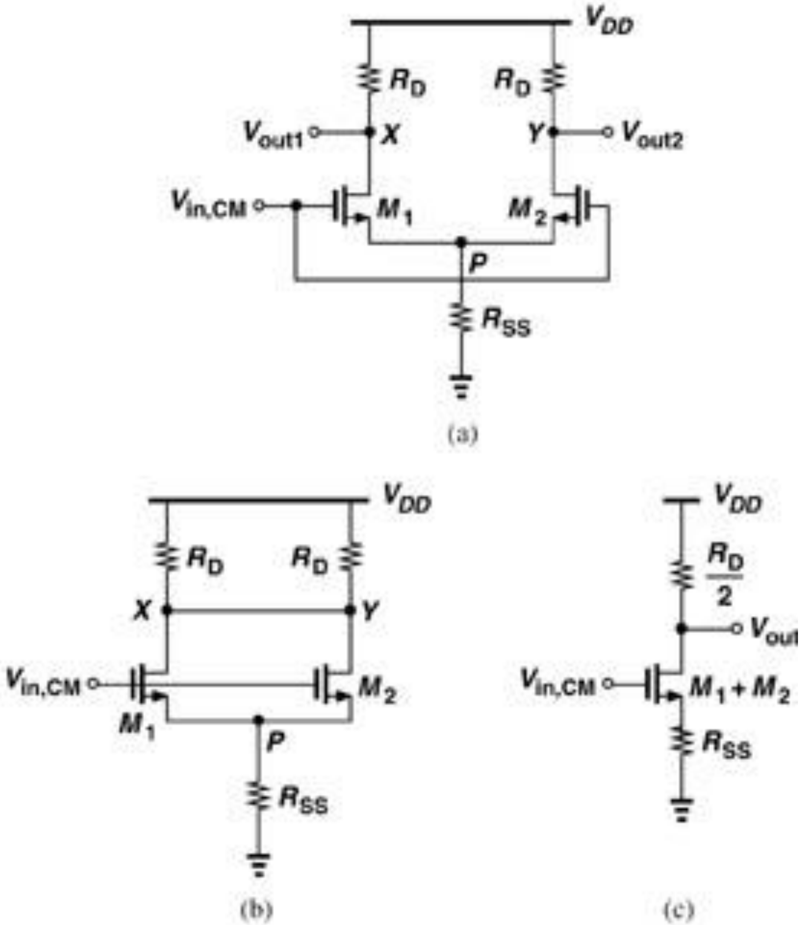
$$A_v = -\frac{g_m R_D}{1 + g_m R_S}$$

$$= -\frac{g_m}{2} R_D$$

Differential gain

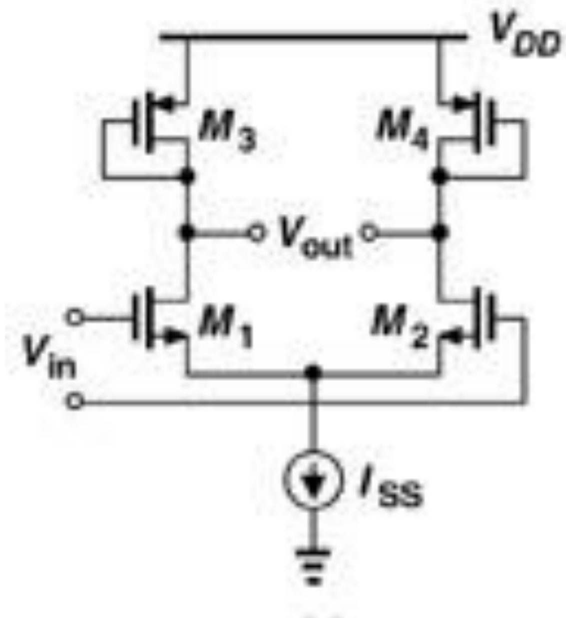
$$A_v = -g_m R_D$$

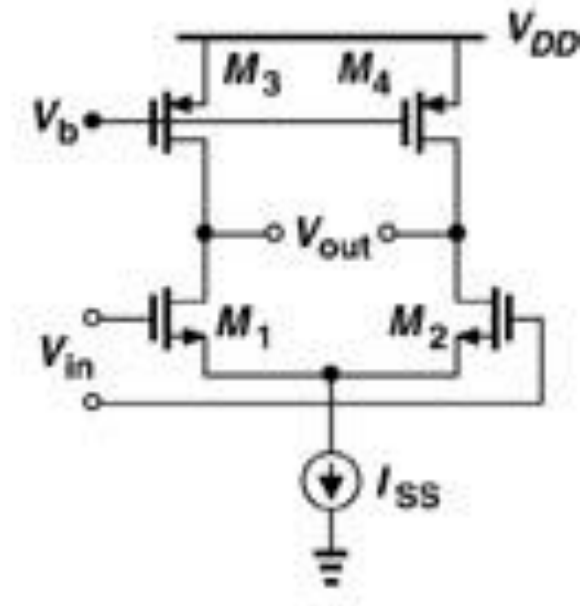
Common mode gain



$$A_v = \frac{V_{out}}{V_{in,CM}} = -\frac{R_D/2}{1/(2g_m) + R_{SS}}$$

MOS loads





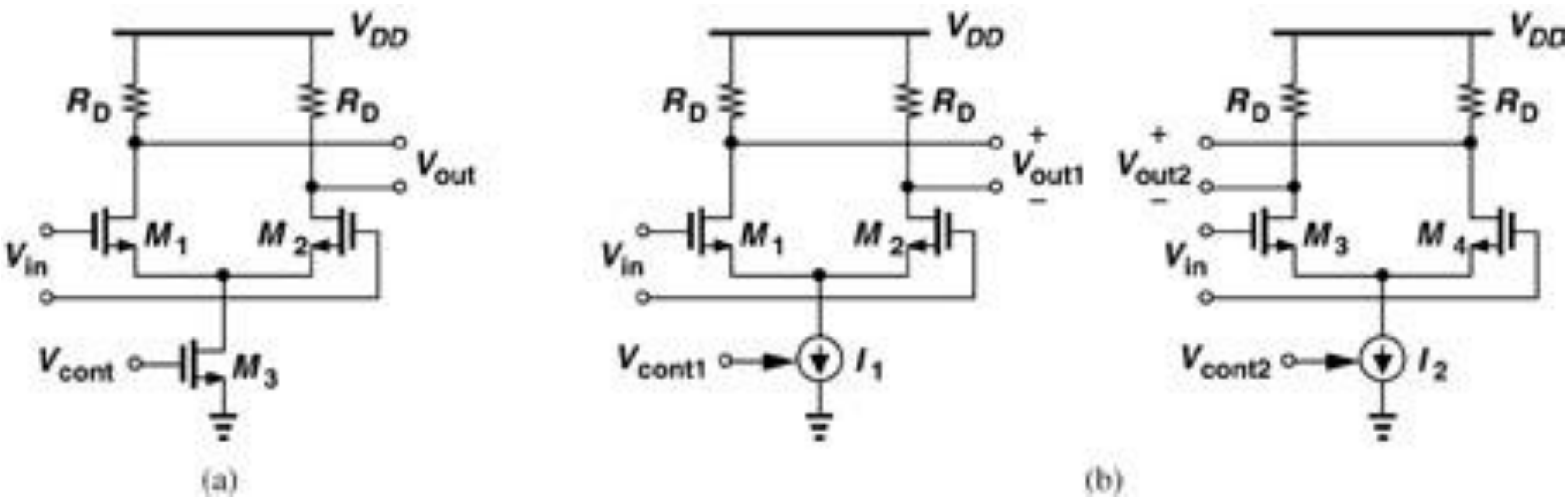
(b)

$$A_v = -g_{mN}\left(\frac{1}{g_{mP}} // r_{oN} // r_{oP}\right)$$

$$\approx -\frac{g_{mN}}{g_{mP}}$$

$$A_v = -g_{mN}(r_{oN} // r_{oP})$$

Variable gain

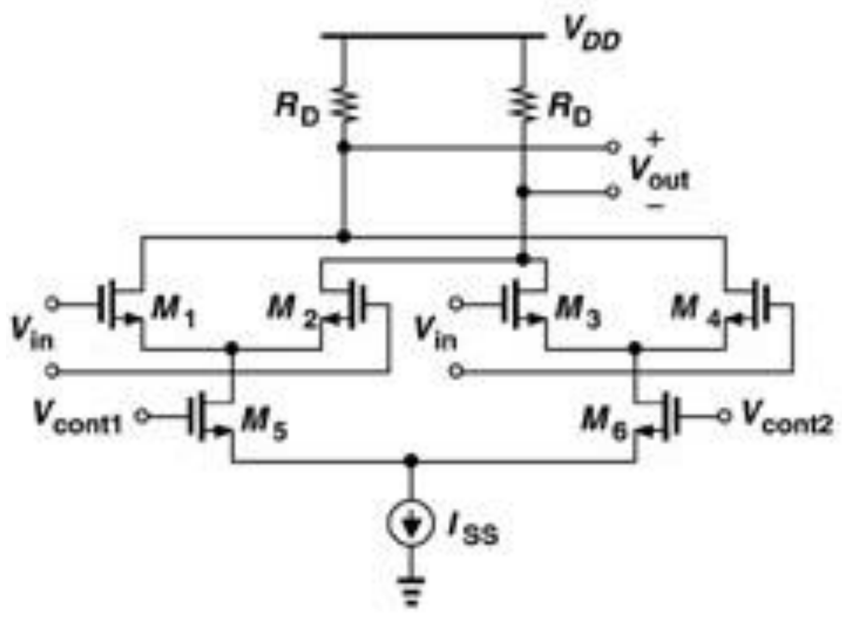


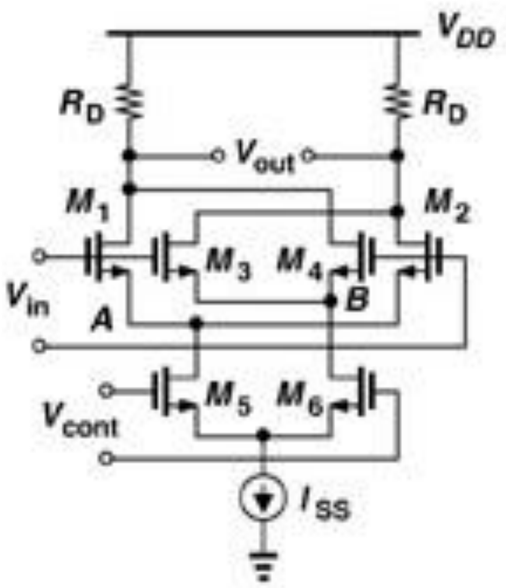
Gain varied by control voltage V_{cont}

$$\frac{V_{out1}}{V_{in}} = -g_m R_D$$

$$\frac{V_{out2}}{V_{in}} = +g_m R_D$$

Gilbert cell





$$V_{OUT} = kV_{in}V_{cont}$$

Widely used in radio circuits as mixer and phase detector