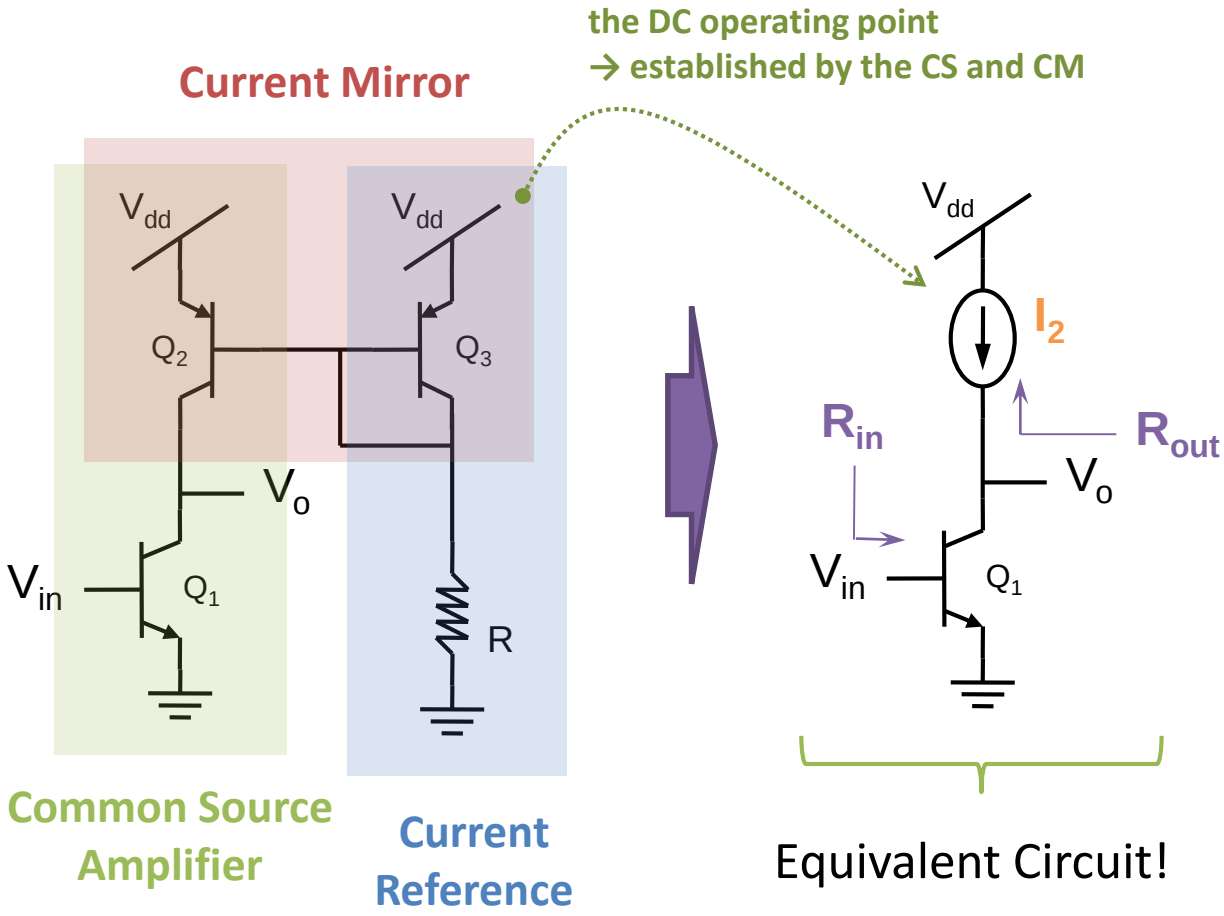
Amplifier with Active Load



- DC Behavior

  $I_R=I_3=?$

  $I_2=?$

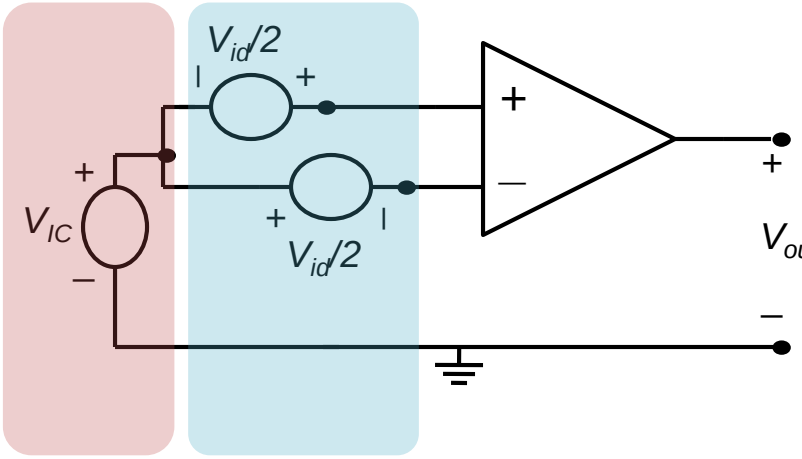
- AC Behavior

  $A_v= V_0/V_{in} =?$

  $R_{in}=?$

  $R_{out}=?$

Differential Amplifiers



$$V_{out} = A_{vd} v_{id} \pm A_{vc} v_{ic}$$

common-mode input voltage

differential-mode input voltage

A_{vd}(ideal) = ∞

A_{vd} – Differential Mode Gain
- **$V_+ = -V_- \rightarrow$ small signal**

A_{vc} – Common Mode Gain
- **$V_+ = V_- \rightarrow$ small signal**

A_{vc}(ideal) = 0

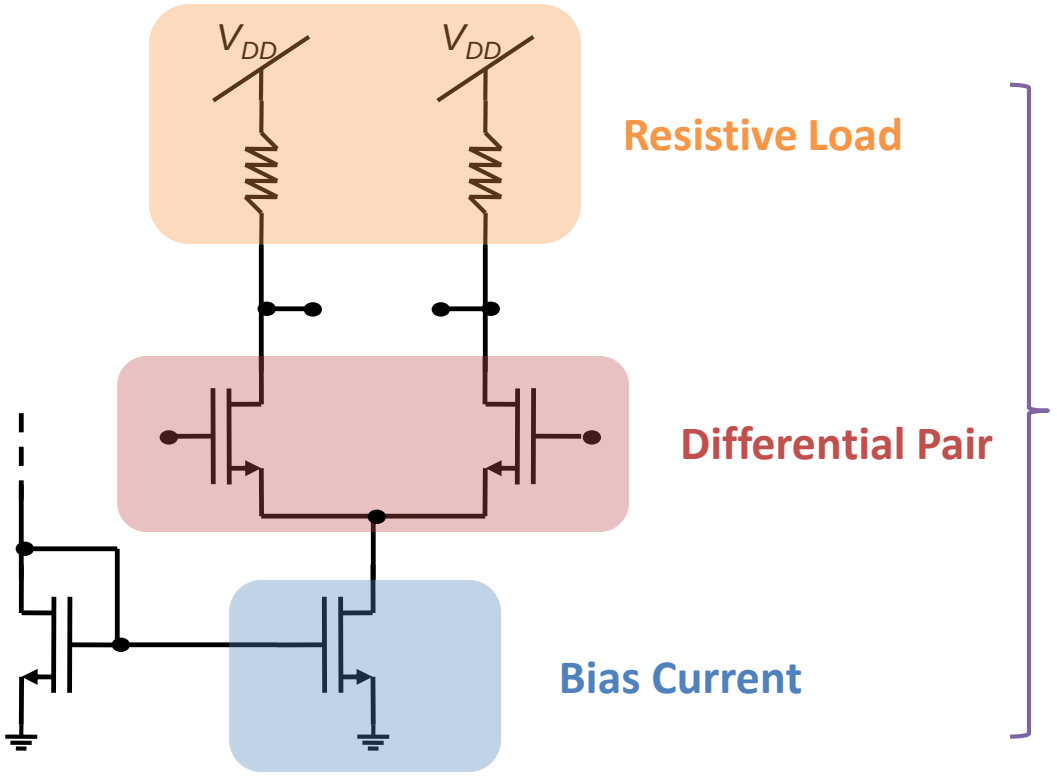
Analysis:
- **Common-mode → small signal**
- **Differential-mode → large signal & small signal**

CMRR – Common Mode Rejection Ratio

$$CMRR = 20 \log \left(\frac{A_{vd}}{A_{vc}} \right)$$

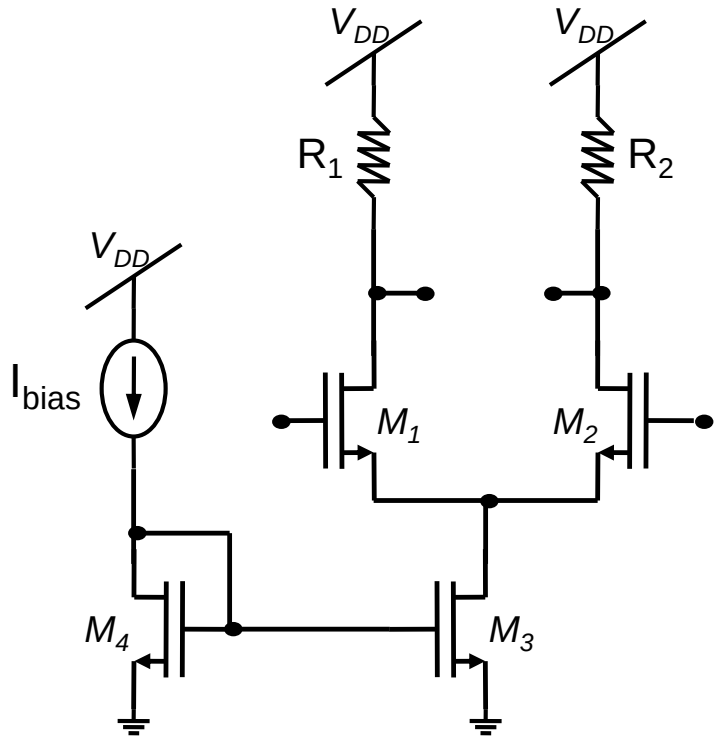
Differential Pair → Chp #8

- Converts the differential input signal into a differential current
- Input stage to almost every amplifier architecture



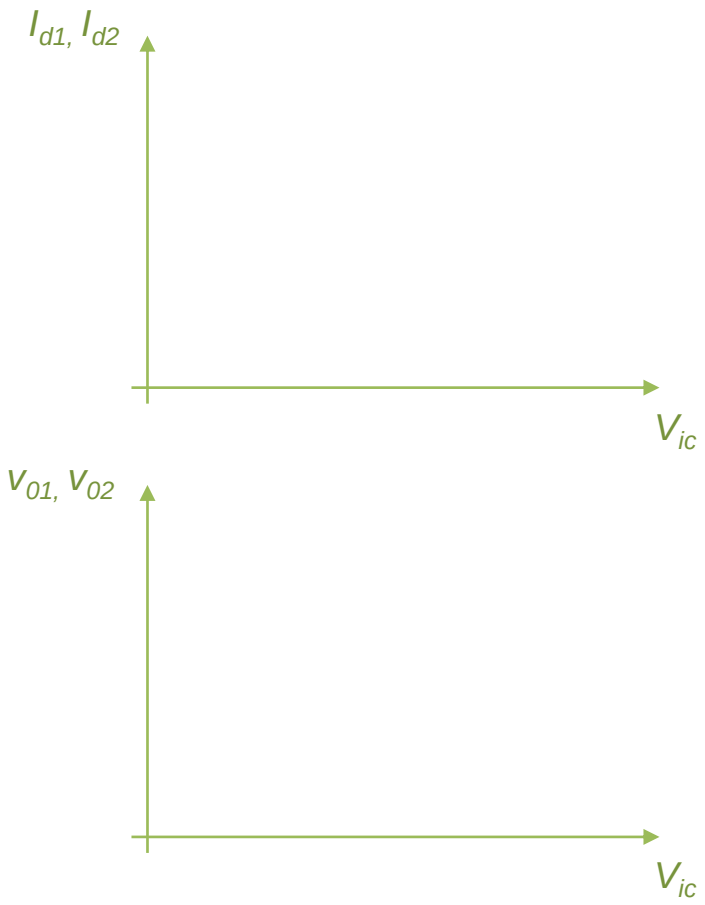
Amplifier Analysis
- DC Behavior ?
  - → Common Mode
- AC Behavior
  - → Common Mode
  - → Differential Mode

Differential Pair Behavior

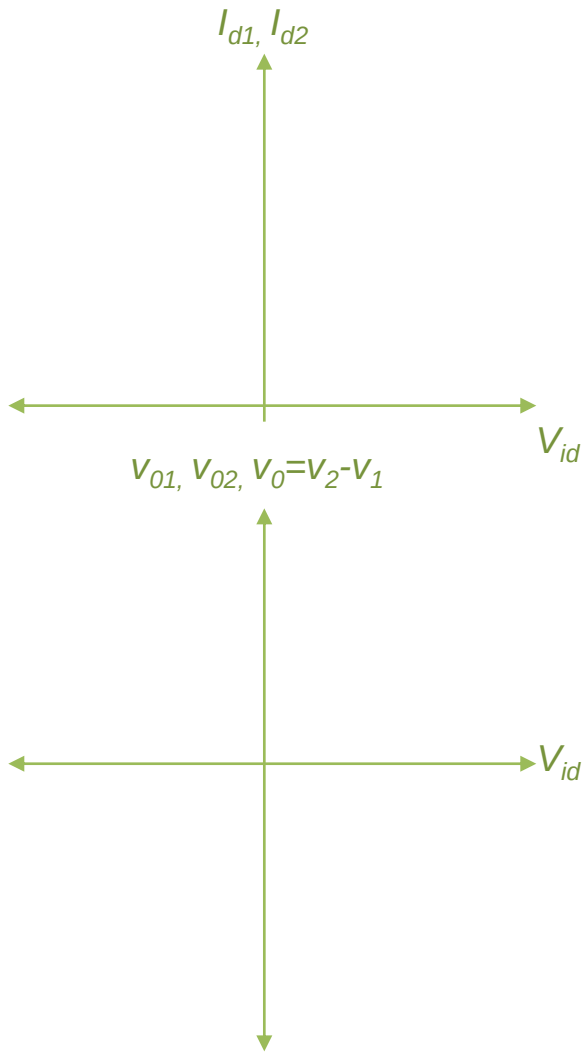


Assume circuit is symmetric with matched parameters

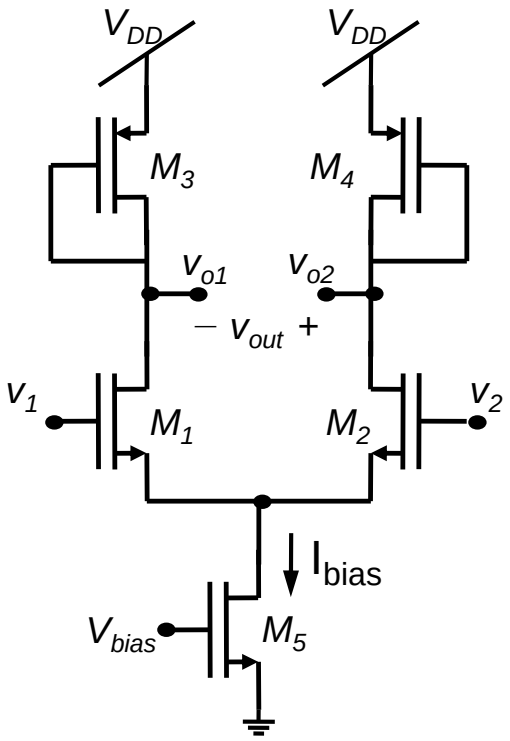
Common-Mode Behavior
$V_1 = V_2 = V_{ic}$



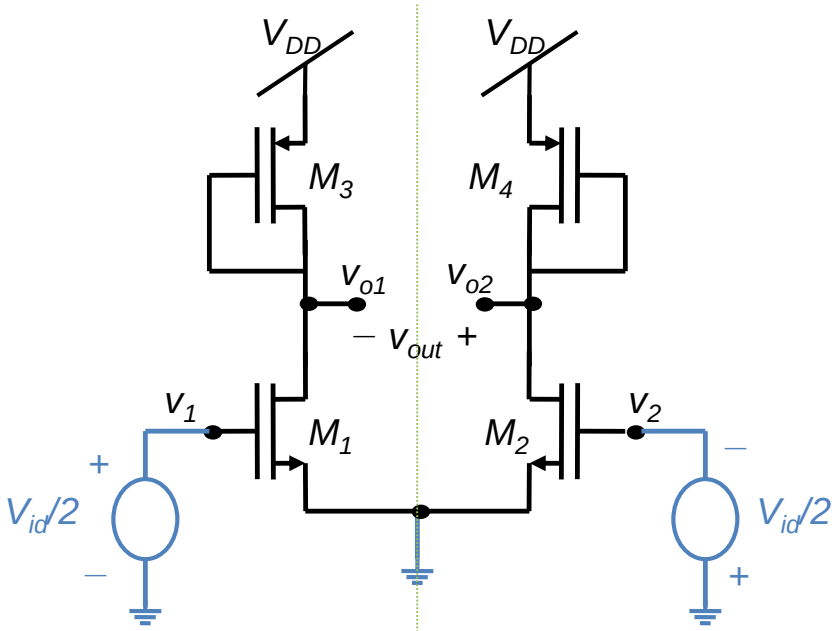
Differential-Mode Behavior $V_1 = -V_2 = V_{id}/2$



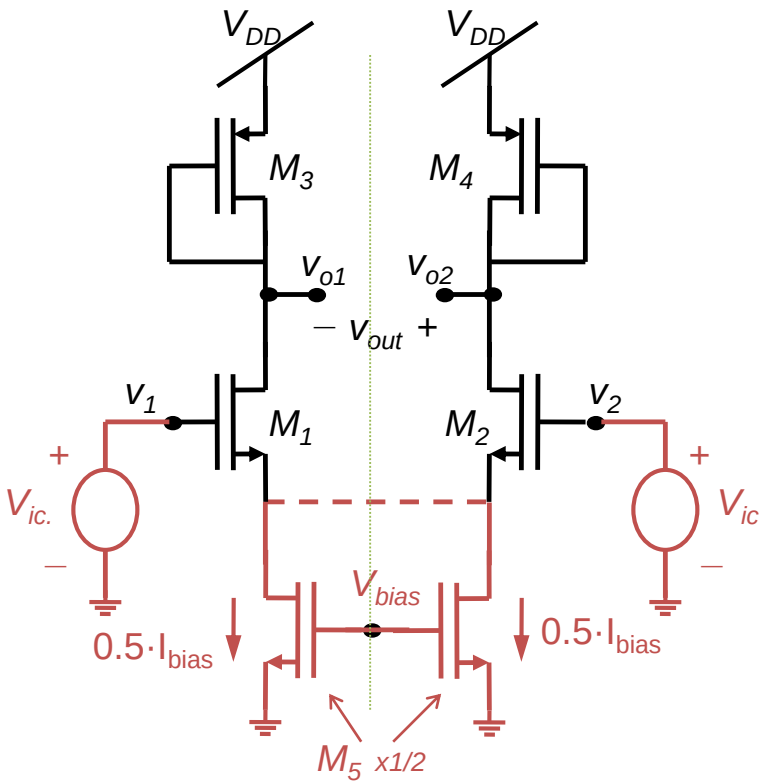
Diff. Pair → Small Signal Analysis



Differential-Mode Circuit



Common-Mode Circuit



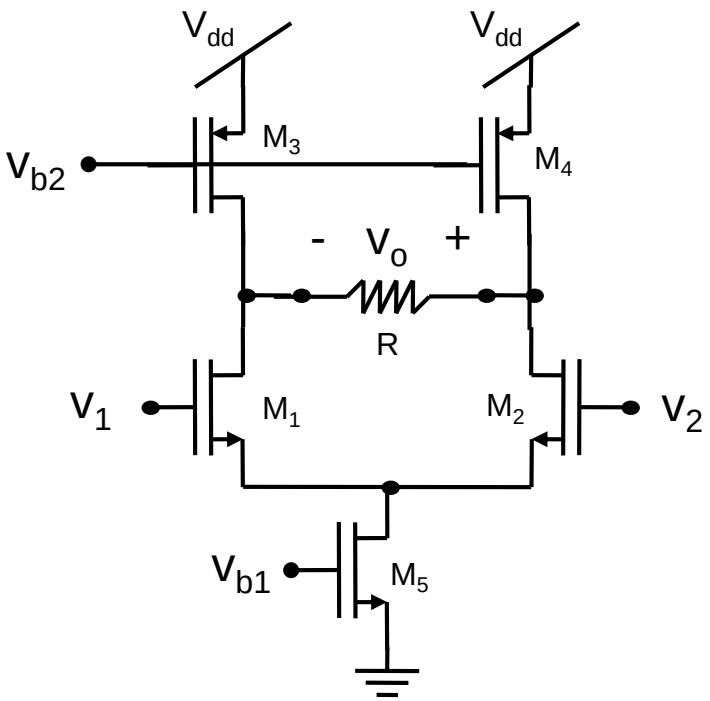
1. Draw symmetric circuit
2. Point in the line of symmetry are equivalent to an **short circuit** / **open circuit**
3. Analyze half circuit

$$A_{vc} = \frac{V_{o2} - V_{o1}}{V_{ic}} = ?$$

$$A_{vd} = \frac{V_{o2} - V_{o1}}{V_{id}} = ?$$

Differential Pair

→ with current source load



Find the expression for:

- A_{id}= ?
- A_{cm}= ?

Assume:

- circuit is symmetric with matched parameters
- V_{b1} and V_{b2} are DC voltages