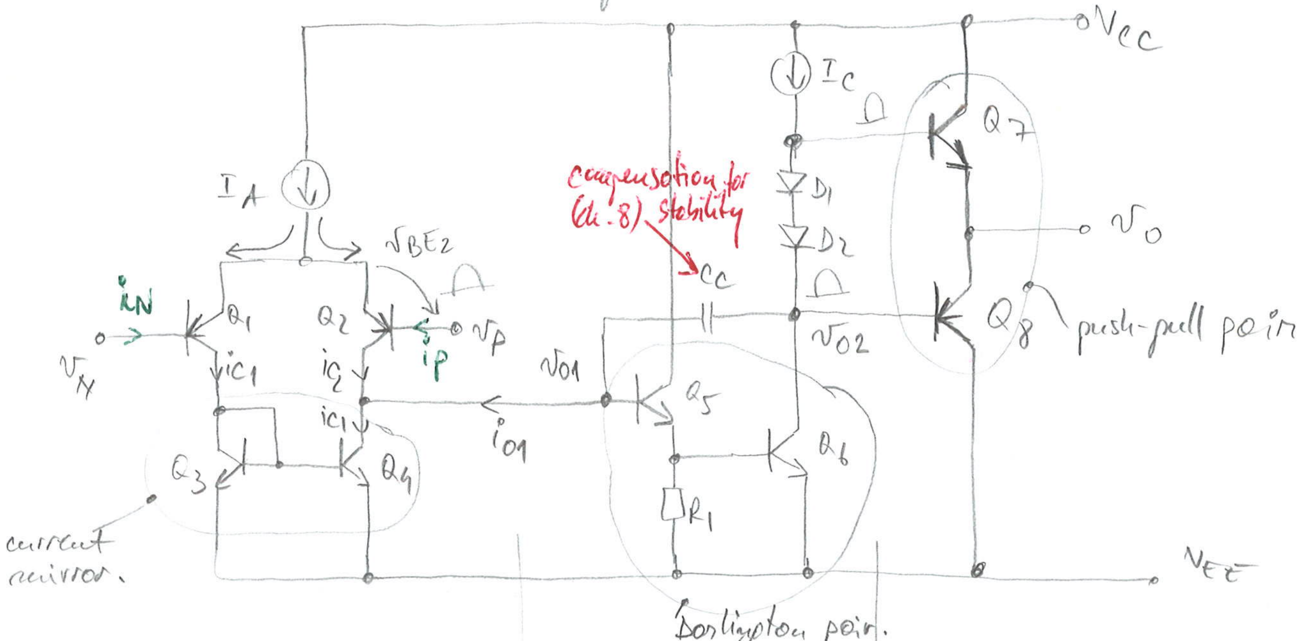
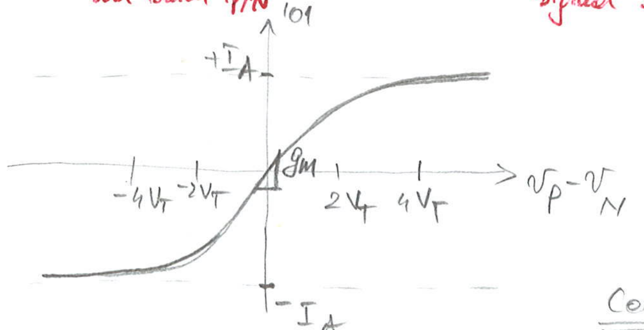
Ch. 5. 5.1 Simplified Op Amp Circuit diagram



← input stage → ← second stage → ← Output stage →

- Provide high input impedance and small i_P, i_N
- Provide more gain and signal swing!
- Provide low output impedance!



$$i_{O1} = g_{m1} (v_P - v_N) \quad (1)$$

↑ input stage transconductance.

Assume $v_N = \text{const}$ stays &

Case 1: $v_P \uparrow \Rightarrow v_{BE2} \downarrow \Rightarrow \begin{cases} i_{C1} \uparrow \\ i_{C2} \downarrow \end{cases} \Rightarrow i_{O1} \uparrow \Rightarrow Q_{5,6}$ move into off state $\Rightarrow v_{O2} \uparrow \Rightarrow \begin{cases} Q_8 \to \text{off} \\ Q_7 \to \text{sat.} \end{cases} \Rightarrow v_{CEQ_7} \to 0.1 \Rightarrow v_O \uparrow$

$i_{O1} = i_{C1} - i_{C2}$

Case 2: $v_P \downarrow \Rightarrow \ldots \Rightarrow v_O \downarrow$

② Pay attention to the small range of $v_P - v_N$ for which we have linear gain!

It can be shown:

$$i_{O1} = I_A \tanh \frac{v_P - v_N}{2V_T} \quad (2)$$

Thermal voltage $V_T \cong 26\,mV$ at room temperature.

From (1) & (2) $\Rightarrow$

$$g_{m1} \triangleq \left. \frac{di_{O1}}{d(v_P - v_N)} \right|_{v_P = v_N} = \frac{I_A}{2V_T} \quad (3)$$

Note: See book by P. Gray for nice analysis & discussion of this!

① "Key take-home" – The input currents i_P, i_N are different from 0. They are needed as the base current for forward biasing of Q_1, Q_2!

- For the detailed analysis of this μA 741 see P. Gray's book { section 6.8. (both dc and small signal analysis)
  { Ch. 10 (Sedra & Smith)
- More on differential pairs { → section 3.5 (P. Gray book)
  { → section 6.1 (Sedra & Smith)
- More on the Darlington pair { → section 3.4 (P. Gray book)
  { → page (675) (Sedra & Smith)
  { → page (544)
- More on the push-pull output stage { → section 5.4 (P. Gray book)
  { → section (9.3-9.5) Sedra & Smith