No. 22

Date . .

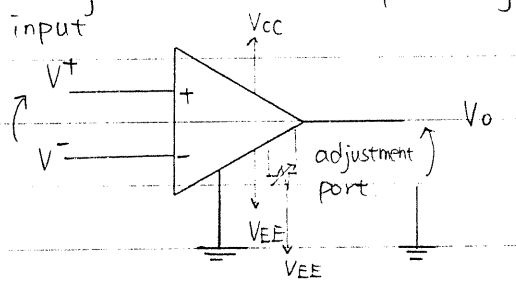
Operational Amplifier (OP, OpAmp)

(i) Basic Building Block of most analog circuit

(ii) function as Ideal (differential) voltage amplifier

DC

Voltage input — Output (sigle Ended)



(Reference)

$V_{diff} = V^+ - V^-$

$V_{EE} < V_o < V_{cc}$

(+0.2V) (-0.2V)

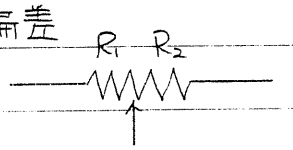
Output voltage swing

$V_{EE} + 0.2 < V_o < V_{cc} - 0.2$

Adjustment port:

DC offset Calibration

偏差



Without calibration

V_o (actual) $\neq 0V$

Ideal Characteristic

⊙⊙⊙ Ideal Voltage Amplifier

(i) infinite input inpedence (Z_{in})

$Z_{in} = \frac{V_{diff}}{I_{diff}} \to \infty$ $1M\Omega \sim 10M\Omega$

$\Rightarrow i^+, i^-$ input current

$\simeq 10^{-6} A$ (1μA)

(ii) Zero output inpedence

$Z_{out} = \frac{V_o}{I_o} \simeq 0$ 10Ω

output is an ideal voltage source

(iii) Infinite open-loop Voltage gain

$A_{Vo} = \frac{V_o}{V_{diff}} \to \infty$ $10^5 \sim 10^7$

$\Rightarrow V_{diff} \to 0$ $V^+ \simeq V^-$

$|V_o|_{max} \simeq 10V \Rightarrow |V_{diff}|_{max} \simeq 10^{-5} \sim 10^{-7} V$

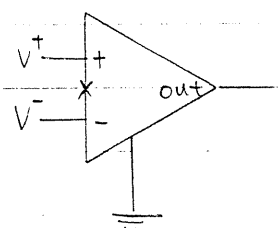
$(A_{Vo})_{db} = 20 \log_{10} A_{Vo}$

$10^5 \sim 10^7 \Rightarrow 100 \sim 140$ db

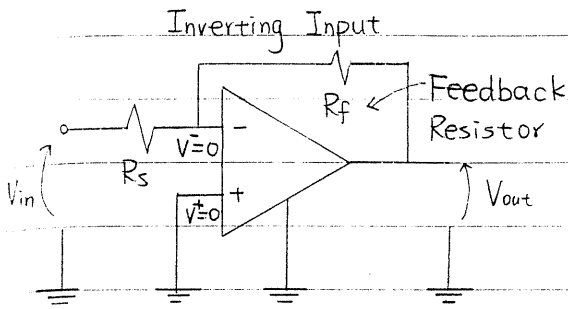
Virtual Node

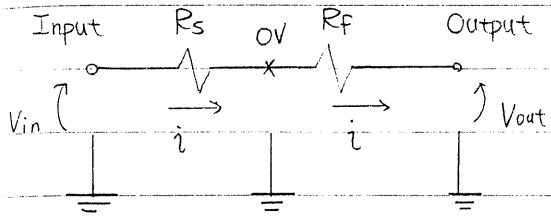
Single input node：不吸收電流

$\because i^+, i^- \simeq 0$



OpAmp Inverting Voltage Amplifier



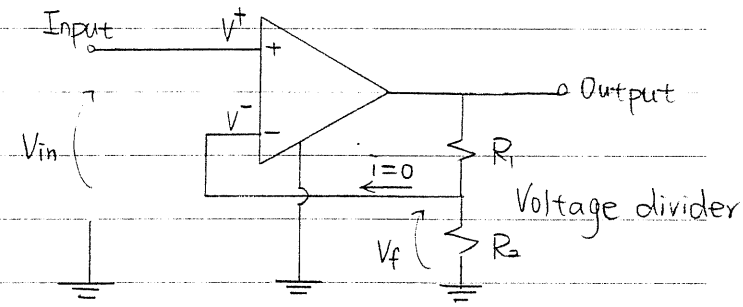


$$\frac{V_{in}-0}{R_s} = \frac{0-V_{out}}{R_f} \Rightarrow \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_s}$$

R_{in} (input inpedence) $= R_s$

R_{out} (output inpedence) $= R_f$

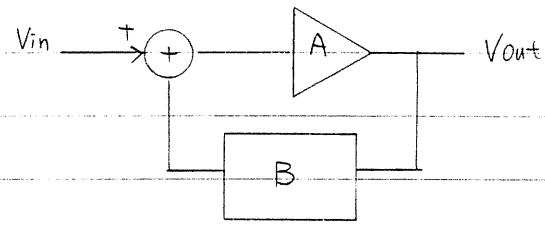
Non Inverting voltage Amplifier



$$V_f(t) = \left(\frac{R_2}{R_1+R_2}\right) V_{out}$$

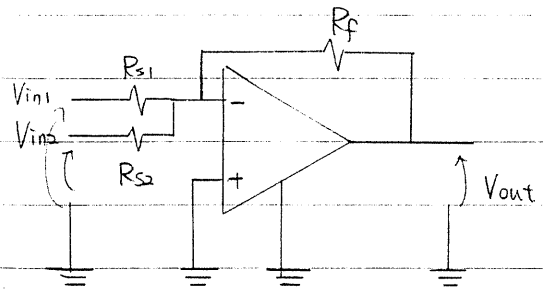
feedback voltage

$V_{in}(t) = V_f(t)$



$$\frac{V_{out}}{V_{in}} = B^{-1} \qquad f A \to \infty$$

Inverting Adder



$$V_{out} = -\frac{R_f}{R_{s1}} V_{in1} - \frac{R_f}{R_{s2}} V_{in2}$$